AUSTRALIA

Australian Bureau of Statistics
INFORMATION PAPER

A GUIDE TO SMOOTHING TIME SERIES— ESTIMATES OF "TREND"

CATALOGUE NO. 1316.0

INFORMATION PAPER

A GUIDE TO SMOOTHING TIME SERIES— ESTIMATES OF "TREND".

IAN CASTLES
Australian Statistician

AUSTRALIAN BUREAU OF STATISTICS **CATALOGUE NO. 1316.0**

(F)

Printed in Australia by Union Offset Co. Pty Ltd, Canberra

CONTENTS/INDEX

INDEX

GRAPHS/CHARTS/TABLES/APPENDIXES

Preface

People invariably use socioeconomic time series data to detect significant changes in the underlying direction of the activity or the occurrence of turning-points, such as peaks, troughs and points of inflexion (points where an apparent developing peak turns into a further rise, or a developing trough turns into a further fall). This interest is particularly keen at the current/topical end of the series, where a timely and reliable indication of the timing and sharpness of the turning-point is desired.

In practice this detection task is made difficult when the raw or original data contains not only the fundamental trend-cycle behaviour of interest, but also appreciable movements attributable to evolving seasonal and trading-day patterns and large irregular influences that might be related to sampling and non-sampling errors as well as unexpected socioeconomic shocks. In order to estimate the trend in such data the seasonal and trading-day variations must be removed and the irregular influences significantly dampened.

Because many important socioeconomic indicators have only been seasonally adjusted, thereby leaving the combined effect of the trend-cycle and irregular influences, users of these indicators have been faced with having to "remove" the irregularity themselves, often by relatively crude means, or of utilising the seasonally adjusted movements as approximations of the trend-cycle changes. In some circumstances these crude measures of the trend can be quite misleading.

This paper discusses the present Australian Bureau of Statistics practice of smoothing various seasonally adjusted series that display highly volatile movements, the rationale behind the procedure employed and the qualifications associated with using such non-definitive estimates of trend-cycle behaviour.

Australian Bureau of Statistics
Canberra
January, 1987

IAN CASTLES
Australian Statistician

Preamble

This Information Paper is not a theoretical statistical essay that demands of its reader considerable statistical or mathematical knowledge. The paper is concerned with issues of applied statistics, and is written as an aid to the everyday user of the Bureau's data.

The Information Paper discusses in a minimal technical manner the relatively complex statistical concepts and notions behind the statistical procedure employed by the Australian Bureau of Statistics to smooth time series. To assist understanding, and to increase appreciation of the usefulness of the smoothing procedure, a number of examples are presented. For the sake of realism and relevance these cases involve major socioeconomic indicators. Wherever practicable, graphical presentation is used to illustrate results, performance or concepts which would otherwise involve long and tedious text or complicated tables.

The structure of the paper is sequential, each part building on what has preceded. Consequently, the general reader is not advised to skip segments of the paper until a clear understanding of the concepts and issues have been obtained.

If the reader requires further information or wishes to discuss aspects of the paper, contact:

Supervisor
Seasonal Analysis
Australian Bureau of Statistics
PO Box 10
Belconnen ACT 2616
062 526103

Introduction to time series analysis

The data: time series

1. As a preliminary, it is important to understand what type of data are and what type of data are not subject to the smoothing process. The attention of this paper is confined solely to time series data. A time series is a statistical record of a particular social or economic activity, like road accidents or factory production, which is measured at regular intervals of time on a long-term basis. Usually the unit of time that is recorded and published is a month or quarter, though some data are recorded weekly. Examples of time series published by the Australian Bureau of Statistics are such things as monthly retail sales and quarterly capital expenditure, both of which appear below in Graphs .1. and .2. respectively. Although monthly series will be focused upon in this paper, the concepts, principles and methods discussed below also apply to quarterly series.

2. Data which are collected "irregularly", "once-off" or only at the end of "long intervals", are not the subject of this paper. Examples of these three types of collection are:

(a) the survey of child care arrangements, which is an example of an irregular collection,

(b) the survey of household usage of electrical appliances, which is an example of a "once-off" collection,

(c) the 1986 Australian Census, which is an example of a "long interval" collection.

Time series decomposition

3. Notionally, a time series can be broken into a number of fundamental components, each of which has its own distinguishing character. For example, in a simple case the original data may be split into the following three components:

(1) a *seasonal pattern,* which repeats each year in a systematic manner,

(2) a *trend,* which loosely speaking indicates the underlying direction of the series,

(3) a *residual* element, which accounts for the remainder of the series' short term behaviour, and when observed appears irregular.

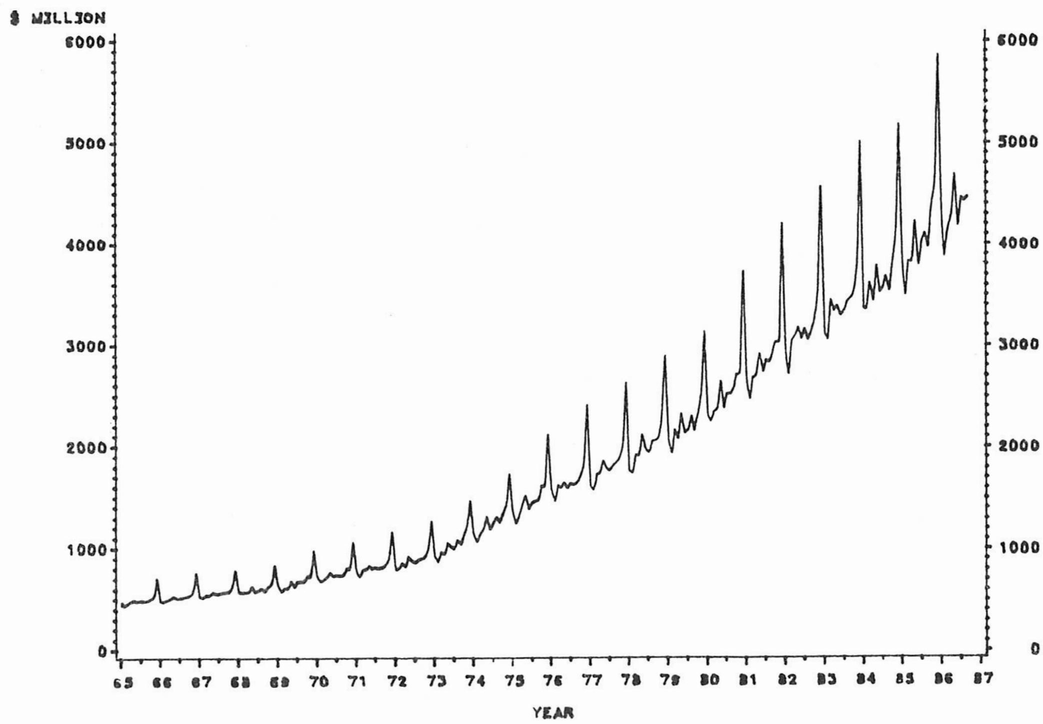
In more complex examples there are time series components such as the "trading-day" pattern and movable holiday influences. The term "trading-day" pattern refers to the effect brought about in the data by the number of high or low activity days varying in any particular calendar month as the years change. A "movable holiday" influence is the effect on the normal activity level of a particular day as a result of a systematic shift in the timing of a holiday. The term *trend* will be used loosely as described above until it is defined and discussed more rigorously later in the paper.

4. In the simple case, when a time series is seasonally adjusted an estimate of the seasonal pattern *only* is removed from the original data; in the complex case the estimated effects of the trading-day pattern and movable holiday influences are *also* removed to obtain the seasonally adjusted series. In all cases, simple or complex, what remains in the seasonally adjusted data is the interplay of the *trend and the residual/irregular* components. Graph .3. below illustrates these concepts for a simple case. Chart 1 of Graph .3. shows the behaviour of the original monthly data over the years. In this case the data are the estimated number of unemployed in Australia. As can be seen from Chart 1 the data vary considerably from month to month over the years. This behaviour of the *original data* is the result of the continual interaction of the *seasonal patterns,* the directional changes in *trend* and the short term *erratic residual* influences. Chart 3 illustrates the seasonally adjusted series obtained by removing the seasonal factors (Chart 2) from the original series. The seasonally adjusted series consists of an estimate of the underlying trend together with the residual influences. Charts 4 and 5 illustrate that the smoothed seasonally adjusted data are obtained by removing the residual influences from the seasonally adjusted series.

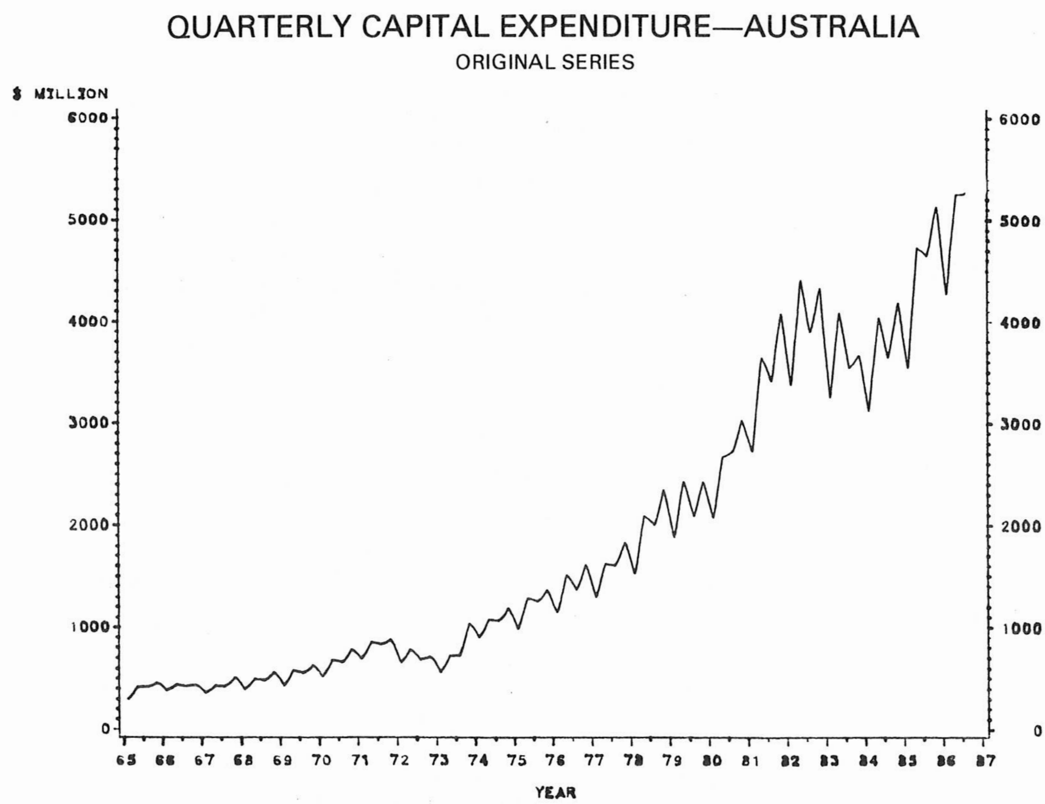
GRAPH .1.

MONTHLY RETAIL SALES—AUSTRALIA

ORIGINAL SERIES



GRAPH .2.



Trend indicators

5. When the user is interested in the behaviour of the trend, the original data are not necessarily or directly helpful as an indicator if it has a noticeable seasonal pattern and/or a large irregular/residual component. Whether the seasonally adjusted data are a good proxy of the trend or not will depend on the relative contribution of the irregular component to the monthly movements, compared to the trend's contribution. For example, Graph .4. below illustrates how the original data of monthly retail sales are quite a seasonal series — each November and December there are very large seasonal increases in sales. When seasonally adjusted, a clearer picture of the monthly trend direction is given because the seasonal pattern has been removed (as well as the trading-day pattern and movable holiday influences) and in this particular case the strength of the irregular influences is very small relative to that of the trend component. However, in the next example illustrated in Graph .5., both the original and seasonally adjusted data for building approvals clearly show that the activity is relatively more erratic than retail sales. In this case neither the original building approvals data nor the seasonally adjusted data give a clear month to month indication of the trend.

GRAPH .3.

UNEMPLOYED MALES AGED 20 YRS AND OVER

CHART 1

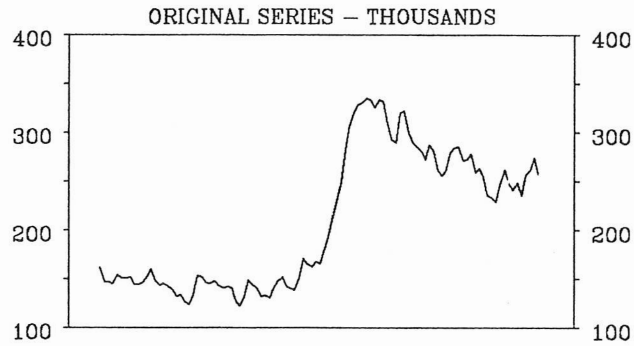


CHART 2

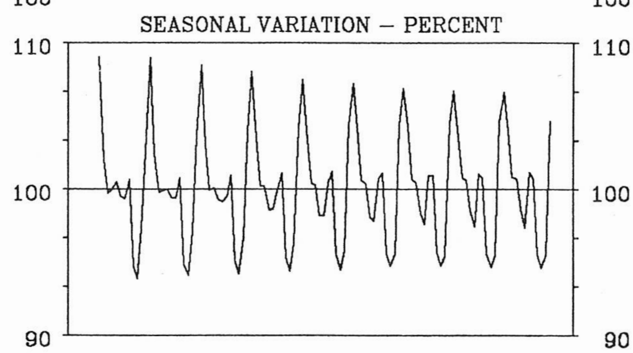


CHART 3

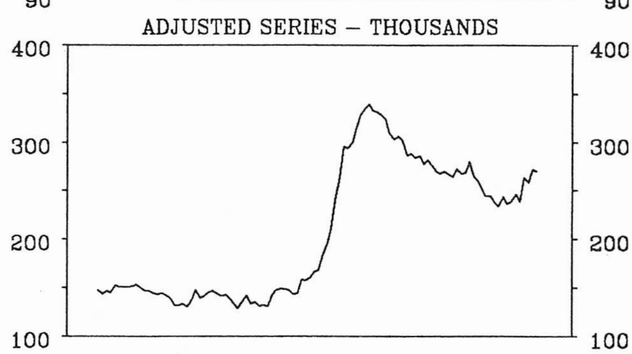


CHART 4

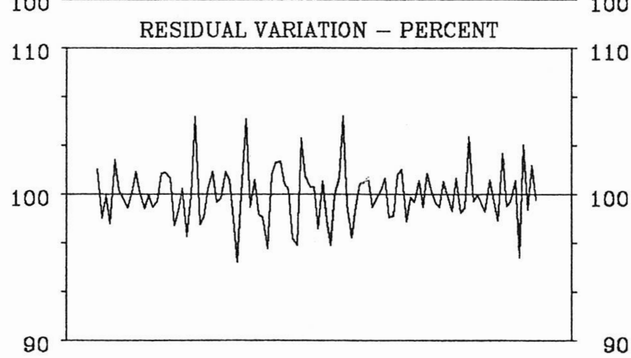
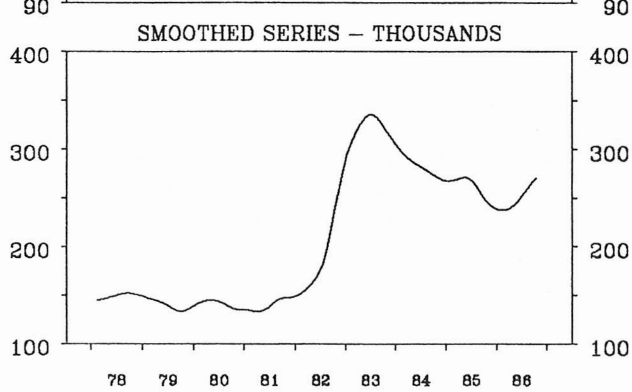
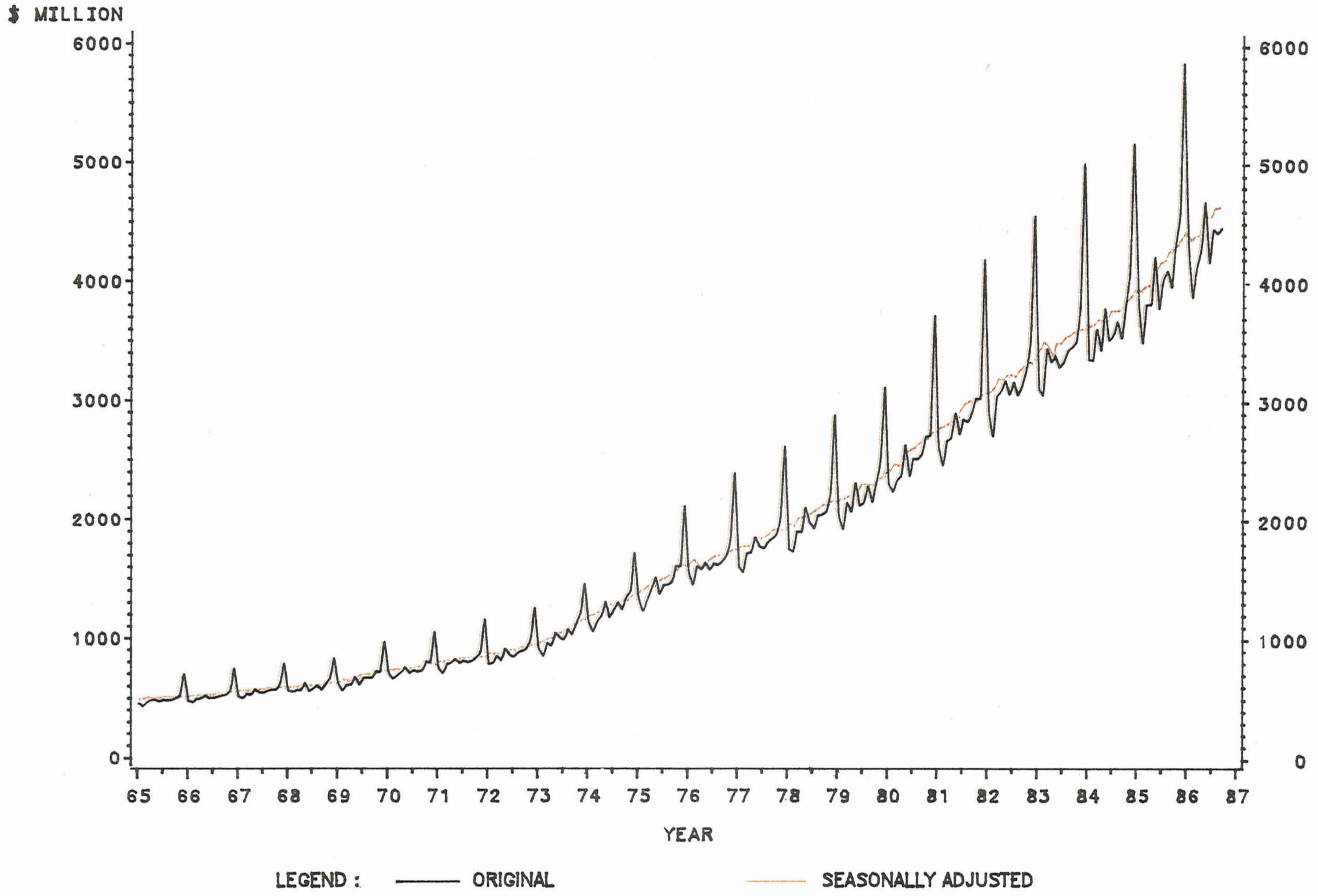


CHART 5

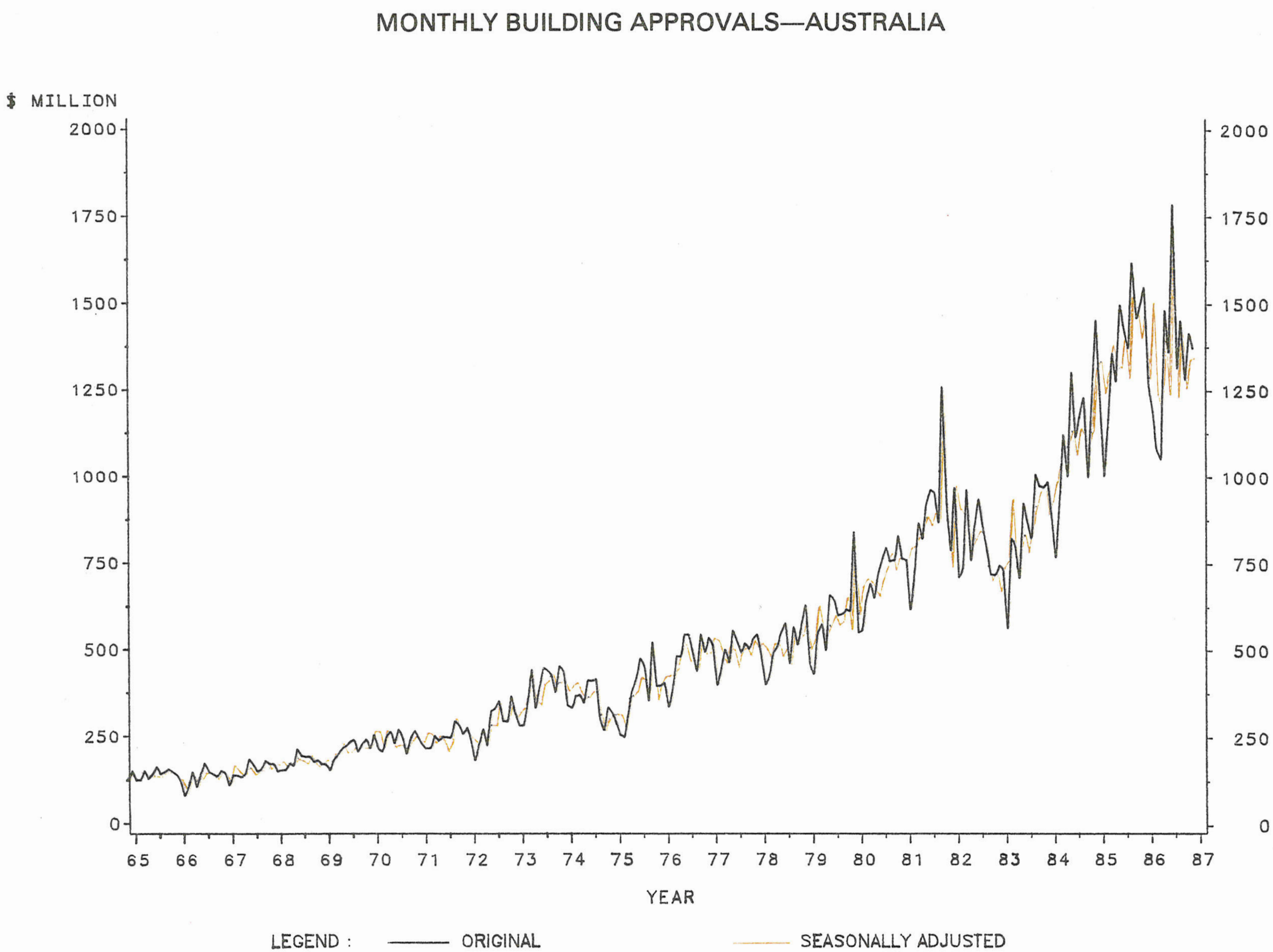


GRAPH .4.

MONTHLY RETAIL SALES—AUSTRALIA



GRAPH .5.


MONTHLY BUILDING APPROVALS—AUSTRALIA
$ MILLION
2000
1750
1500
1250
1000
750
500
250
0
65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87
YEAR
LEGEND : ORIGINAL SEASONALLY ADJUSTED

6. It can be seen from Graph .5., though, that the seasonally adjusted data do not generally vary by as much as the original data, this is because the seasonal and trading-day variations have been removed from the original data. However, the seasonally adjusted data do still exhibit a lot of irregularity, consequently making it also a poor indicator of trend in its own right. The irregular nature of this seasonally adjusted data is not a deficiency of the seasonal adjustment process, as some users have thought in this and similar cases. By definition the seasonal adjustment process must retain in the seasonally adjusted data all of the irregular/residual influences present in the original data, along with the trend component.

The task

7. In cases where the original data contain not only the trend behaviour of interest but also appreciable movements attributable to seasonal and trading-day patterns, frequently evolving, as well as large irregular influences, an attempt to discern the trend requires that the data be seasonally adjusted and the influence of the irregular dampened. This paper does not attempt to explain how series are adjusted for seasonal or trading day patterns, but takes as given that the seasonally adjusted data are published. The procedure considered in this paper is a cost-effective means for dampening irregularity in time series so as to provide timely and reliable indicators of trend behaviour.

Some options

8. In principle, one means of dampening the irregularity would be to remove it from the data after having identified the timing of the "irregular" and quantified it in a causal sense using detailed subject matter knowledge. Experience in the Australian Bureau of Statistics has been that while it is sometimes possible to relate the timing of apparent irregulars directly to socioeconomic events or compilation hitches, it is not possible to quantify many of them confidently. This problem is particularly aggravated at the current end of the series, especially given the normal time and staff constraints associated with producing timely indicators. For general application this causal quantification option for "removing" the irregularity has been rejected on the grounds that it is not cost effective or feasible. Instead, an operationally simple and impartial statistical procedure has been adopted for general application. The procedure used is referred to as *smoothing* or *filtering.*

The need for three indicators

9. Presently the Australian Bureau of Statistics is progressively smoothing a growing number of seasonally adjusted series that are highly irregular. It is anticipated that as more seasonally adjusted data are provided for smaller regional and functional splits, such as industry, sex, age, etc, these indicators will be more irregular and the number of smoothed series will increase. However, the provision of smoothed seasonally adjusted series is not intended to replace either the original or seasonally adjusted data. The smoothed series are provided as a supplement or complement to the original and seasonally adjusted data because they can provide additional useful information to the user.

Other requirements

10. To illustrate why the smoothed seasonally adjusted data are not a blanket replacement indicator the following observations are made. In its own right the smoothed seasonally adjusted series can only provide information about the trend behaviour. There are users, however, who are not solely interested in the trend. Some users may be interested in the characteristics of the seasonal pattern. For example their concern may be:

- the relative magnitudes of the seasonal peaks and troughs within the series, and between series,
- how the seasonal peaks and troughs are spread throughout the year,
- how the seasonal peaks and troughs have changed/evolved over the years.

Some users may be interested to know which months are the most or least *irregular,* by how much, and how the irregularity is changing over time. The above information with respect to the seasonal pattern and irregular variations can be useful when considering when to introduce overlapping new data collections. Users may also be interested in the analysis of *seasonally adjusted* data to explain history and produce forecasts. They may, for example, relate the substantive movements in the trend and irregular components with economic events and changes in government policy.

The difference

11. The difference between the original indicator series and the seasonally adjusted series is the combined estimated effects of the seasonal, trading-day and movable holiday influences that have been removed from the original series. The difference between the seasonally adjusted series and the smoothed series is the estimated effect of the irregular influences. As will be seen below, careful use of all three indicators is required when making inferences about trend behaviour, particularly at the current end of the series.

Trend estimation using smoothing filters

The smoothing procedure

12. The smoothing or filtering procedure used presently by the Australian Bureau of Statistics is based on a set of *moving averages* that are known to have certain desirable characteristics consistent with the Bureau's objectives and resource considerations. They efficiently dampen down the apparent irregularity in series, do not generally distort the timing of turning points and are relatively reliable and timely estimates that are, comparatively speaking, cheap and easy to produce. These moving averages are known as the HENDERSON moving averages, named after their developer, Mr Robert Henderson. They are a class of moving averages that form an integral and important part of the seasonal adjustment process used by the Australian Bureau of Statistics and many overseas statistical agencies. Consequently it is rational to consider them for smoothing the seasonally adjusted series. However, for the purpose of smoothing or filtering there are also other statistical procedures which are not discussed here. Below, the properties of the Henderson moving averages are discussed.

Averages

13. There are a number of forms an average may take. There are for instance:

- arithmetic averages
- geometric averages
- harmonic averages
- quadratic averages

Throughout this paper the term *average* will be used to refer only to various types of *arithmetic* averages. The properties and purposes of other averages are not discussed here. Arithmetic averages may take either a *simple* or a *non-simple* form. For example, a *simple 13 term average* would be calculated by adding together 1/13th of each of the 13 consecutive observations that the average spans. That is, each observation in the simple 13 term average is given an equal weight of 1/13. In a *non-simple 13 term average* each observation in the calculation *doesn't necessarily have an equal weight.* For instance, the weighting pattern may be such that 1/24 of the first and thirteenth observations are added to 1/12 of the intervening eleven observations. This is only one example of a *non-simple 13 term average*, there are others, one being the 13 term Henderson average which will be described and discussed in more detail below.

Moving averages

14. Whether an average is a *simple* or *non-simple* one, it may be applied to either the whole time series or to successive subperiods of it, thereby producing a time series of averaged values. In this latter case the results are said to have been produced from a *moving average*. For example, when taking a *13 term moving average* of a time series the average of the first 13 consecutive observations would be calculated and recorded as the smoothed value corresponding to the 7th observation of the series being averaged. Next, one would move along the series one observation, dropping out of the calculation span the first observation and bringing in the fourteenth observation. The average of these 13 consecutive observations would then be recorded, and the process of moving along the time series one observation at a time would be repeated, thus creating a smoothed series.

Properties—damping and time shifting

15. Moving averages have two important properties, one is their *smoothing effect*, the second is their *time shift or phase shift effect*. These *two* properties are illustrated below. Graph .6. shows the seasonally adjusted unemployed Australians series smoothed by using a *13 term Henderson moving average* compared to smoothing the same series over annual periods with a simple *12 term moving average*, as some analysts might do. In the latter case the results have *incorrectly* been placed at the right hand end of each of the periods spanned, so as to illustrate time phase shifting. This example clearly demonstrates that the *incorrectly off-centred simple 12 term moving average* has misrepresented the timing of all the major turning points that have occurred in the unemployed series; it has them occurring about six months later than they actually did. It shows unemployment falling through 1981 when it started rising, and it shows rising unemployment in 1983 when it had peaked and was falling. The off-centred simple 12 term moving average is said to have a time phase shift of about six months. A more detailed discussion of time phase shifting properties will follow later. It is evident from the graph, however, that both averages have smoothed out much of the monthly variations in the seasonally adjusted series, but each has done so to differing degrees.

16. In the above case the smoothed seasonally adjusted series produced by the 13 term Henderson moving average has been obtained by placing/recording the results of the averaging process correctly at the centre of the 13 month averaging span, that is, on the seventh of the 13 consecutive observations. If the results of the simple 12 term moving average had been recorded correctly they would lie between the sixth and seventh consecutive months of the averaging span, and not on the twelfth, refer to Chart .6. below. It is clear that centering the simple 12 term moving average will eliminate the time phase shift problem; in Graph .6. the reader needs only by "eye" move the plot of this series to the left by five to six months to see this. It is evident, however, that the simple 12 term moving average has some other deficiencies with respect to estimating the level of the series, the sharpness of the turning points and the presence of points of inflexion. For instance, the maximum level of unemployment is underestimated (never going above 700 thousand), the sharpness of the 1983 peak has been broadened, and the quasi-point of inflexion in early 1985 has been missed altogether.

GRAPH .6.

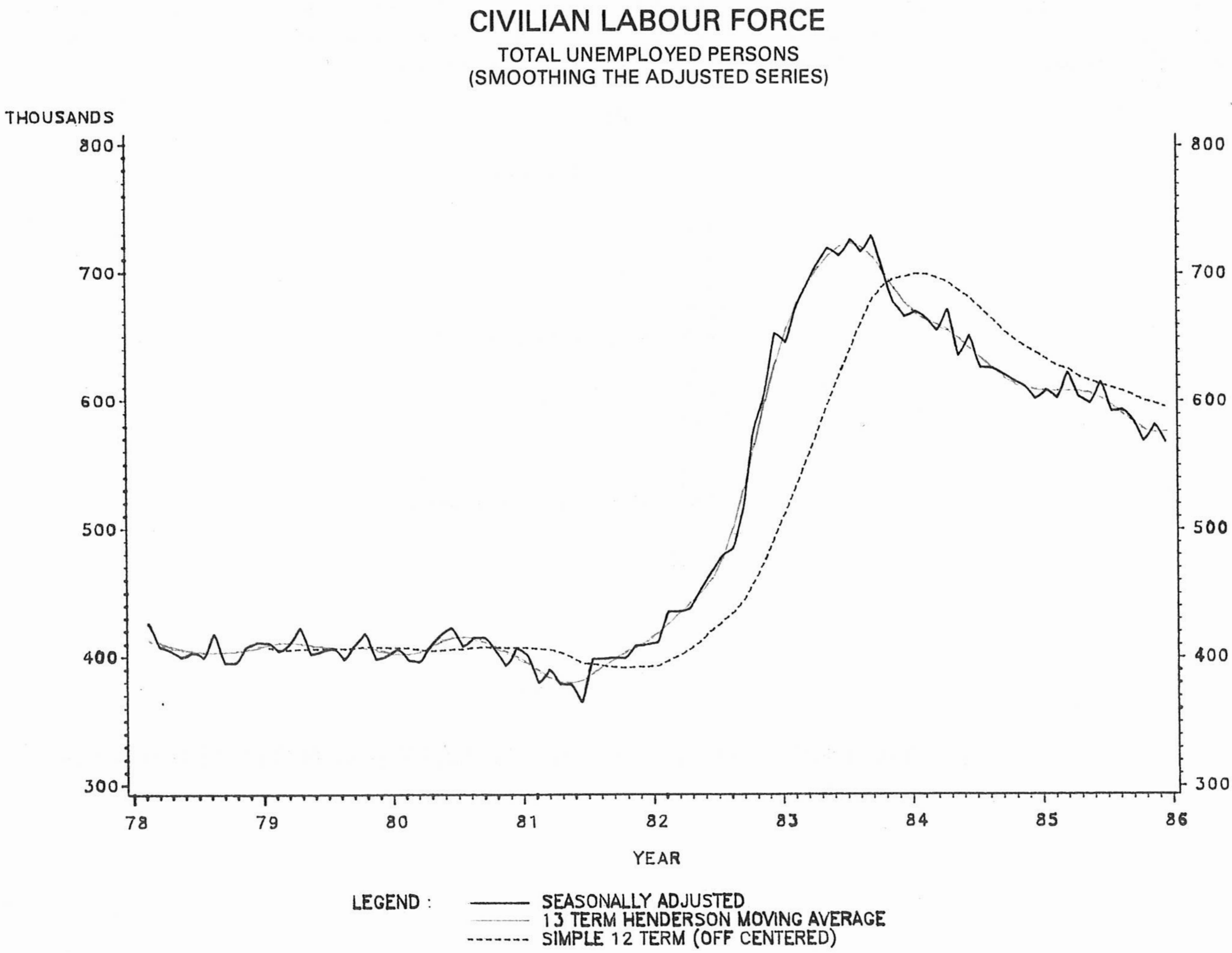


Chart .6.

Averaging span

Observation	1	2	3	4	5	6	7	8	9	10	11	12
Average Value Position							* Correct					* Wrong

Symmetry of moving averages

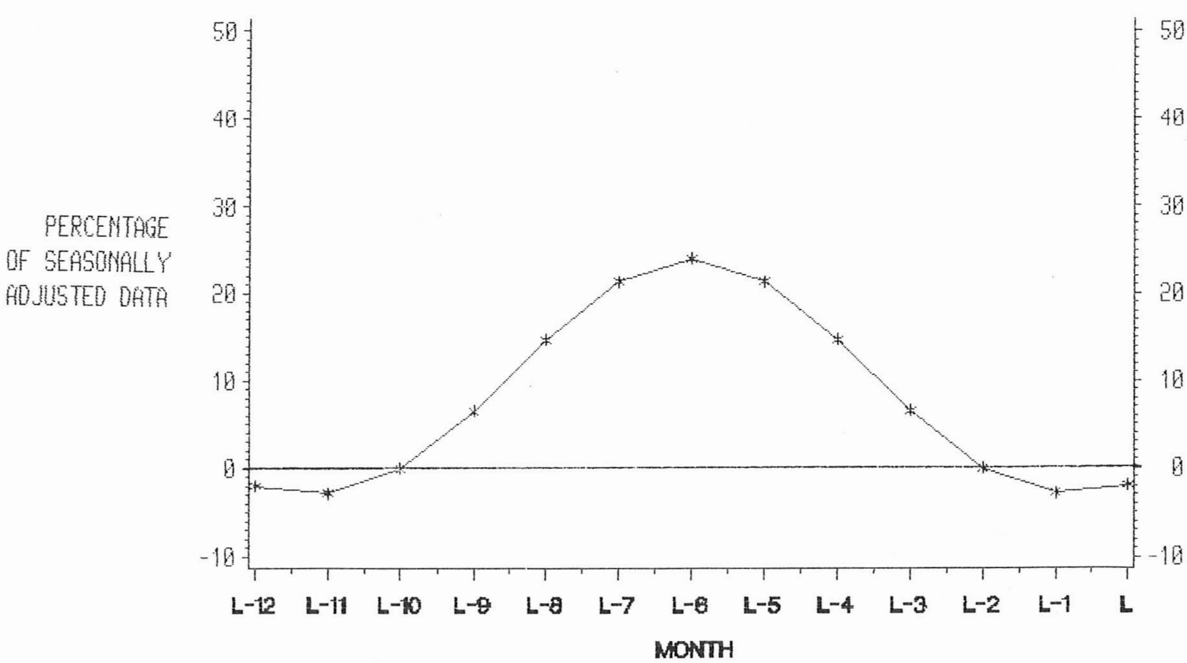
17. Whether a moving average is of the *simple* or *non-simple* form, it may also be described as being *symmetric* or *non-symmetric*. This property is determined by the weighting pattern of the moving average. Below the weighting pattern of the 13 term Henderson moving average is detailed in percentage form, that is, the percentage of each observation that is to be added together with the rest. The order is first to thirteenth in the averaging span.

TABLE .1.

-1.9%	First observation
-2.8%	
0.0	
+6.6%	
+14.7%	
+21.4%	
+24.0%	Seventh observation
+21.4%	
+14.7%	
+6.6%	
0.0	
-2.8%	
-1.9%	Thirteenth observation
100.0%	

GRAPH .7.

WEIGHTING PATTERN OF 13 TERM HENDERSON MOVING AVERAGE



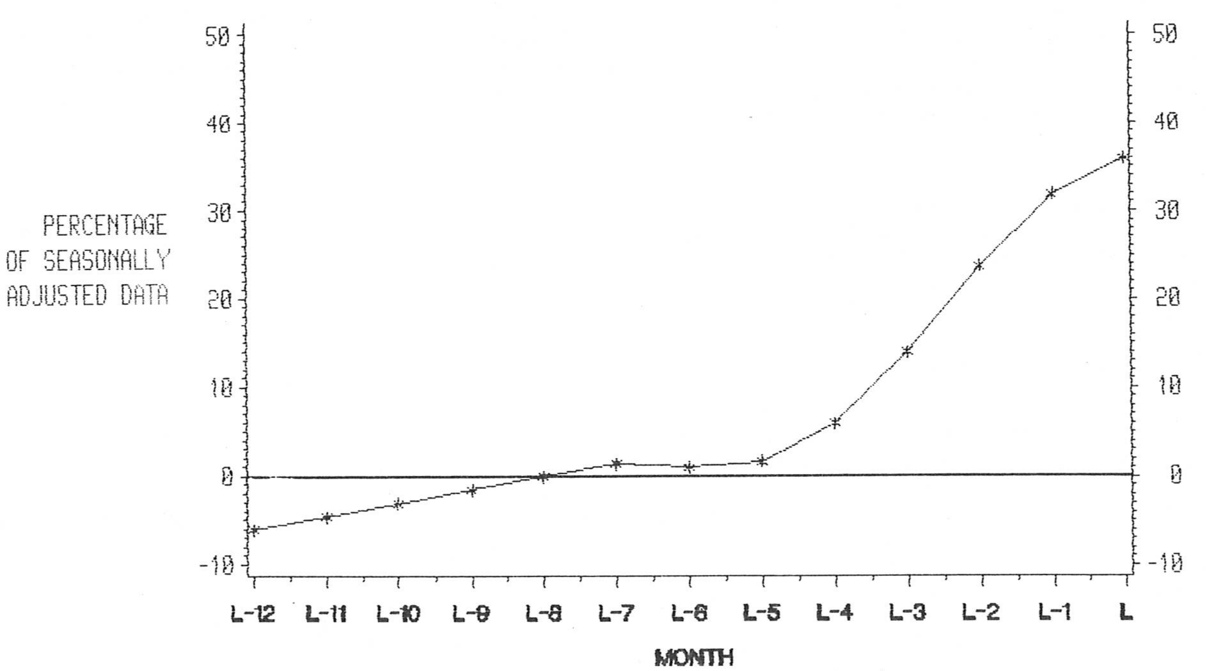
It can be seen from Table .1. and Graph .7. above that the weighting pattern is *symmetric* about the central observation of the averaging span. It will be shown later in paragraph 54 why it is important to know/appreciate these weighting patterns when odd events or perturbations occur. *Simple moving averages,* like the simple 12 term are also described as *symmetric* moving averages, because they are statistical measures of central tendency. The non-simple 13 term moving average whose weighting pattern is 1/24, 1/12, 1/12, ... 1/12, 1/12, 1/24 is also referred to as a *symmetric non-simple moving average*. There are, however, *non-simple moving averages that are non-symmetric.* For example the Sutcliffe *non-simple 13 term moving average,* detailed below in Table .2. and Graph .8., is a non-symmetric case of 13 term length also . The value of this average is positioned on the thirteenth observation of the averaging span, where the weighting pattern is concentrated.

TABLE .2.

-6.1%	First observation
-4.6%	
-3.1%	
-1.6%	
0.0	
1.4%	
1.0%	Seventh observation
1.6%	
5.9%	
14.0%	
23.7%	
31.9%	
35.9%	Thirteenth observation
100.0%	

GRAPH .8.

WEIGHTING PATTERN OF 13 TERM NON-SYMMETRIC NON-SIMPLE SUTCLIFFE MOVING-AVERAGE



Time phase shifting

18. It is essential to note that *symmetric moving averages will not cause time phase shifting*. However, *non-symmetric moving averages do cause time phase shifting to varying degrees*. It should also be recalled that *off-centering a simple moving average which would otherwise have no time phase shift will also cause time phase shifting,* as described above in paragraphs 15 and 16, and Graph .6.

19. In order to *avoid time phase shifting* the Australian Bureau of Statistics uses *symmetric moving averages,* without off-centering, wherever possible. Also, in order to place these non-time phase shifted results meaningfully on observable time intervals, the Bureau uses *odd* length averaging spans. As indicated above in paragraphs 16 and 17, a 13 term symmetric moving average is *centered* on the seventh value of the 13 month span it averages. A 12 term simple symmetric moving average has its value between the sixth and seventh month, which is not observable in the data published. Placing the centered value of the simple 12 term moving average on the sixth or the seventh months introduces a slight time phase shift of half a month either way; placing the average on the twelfth value introduces a half year delay in the movements of the trend behaviour. Similarly, if a simple 4 term moving average was applied to quarterly data and the results off-centered to the last value of the averaging span the time phase shift introduced would be nearly two quarters or half a year.

Odd versus even length

20. It can be seen from the above discussion that, for symmetric moving averages, an *odd* length averaging span centres the averaged value on an observable and publishable observation point. However, *even* length averaging spans centre the averaged value between the periods, or involves the user introducing a half month or half quarter time phase shift. Users of *even* length or *off-centered* moving averages should assess whether the consequential time phase shift they have introduced is detrimental to their analysis of the timing of trend behaviour. The Australian Bureau of Statistics uses odd length symmetric moving averages wherever possible.

Tracking potential

21. Another important feature of moving averages is that a *simple moving average*, that is, an equally weighted one, can, strictly speaking, only accurately reproduce straight line segments that appear in the data to which it is applied. When it encounters curves corresponding to turning point peaks or troughs, or points of inflexion, it can only approximate them, as seen in Graph .6. above. Below, Graph .9. highlights the potential problem. Series A is the benchmark data, artificially constructed with curved and straight line segments; the curves are composed of quadratic and cubic forms. Series B is the data smoothed with a symmetric non-simple 5 term Henderson moving average and series C is the data smoothed with a simple 5 term moving average, that is, equally weighted by 1/5th over its span. It is evident that the simple moving average does not perform very well. However, the 5,7,9, etc, Henderson moving averages will all follow/reproduce the same cubic polynomial form. It should be noted that the simple moving average technique loses observations at the start and end of the series if time phase shift is avoided by centering. However, pronounced time phase shift is introduced if the results are off-centered, and twice as many observations at one end of the series are still lost. Details of some Henderson weighting patterns are in Appendix A.

22. Whereas the *simple moving average* has difficulty with non-linear segments of the series, the *non-simple symmetric Henderson moving average* has been specifically designed to reproduce not only straight line segments but also the quadratic and cubic forms associated with peaks, troughs and points of inflexion. *The Henderson moving average will follow a cubic polynomial trend without distortion, whereas a simple moving average will not*; the specific weighting pattern of any Henderson moving average is designed to guarantee this.

Relevance to real series

23. Because most of the major socioeconomic time series are not well approximated by straight lines, but do instead have curves in their history such as peaks and troughs, points of inflexion and periods of accelerating or declining growth, which are better approximated by mixtures of linear, quadratic and cubic functions, the Australian Bureau of Statistics prefers to use moving averages that have a better chance of representing those trend characteristics than do the simple moving averages.

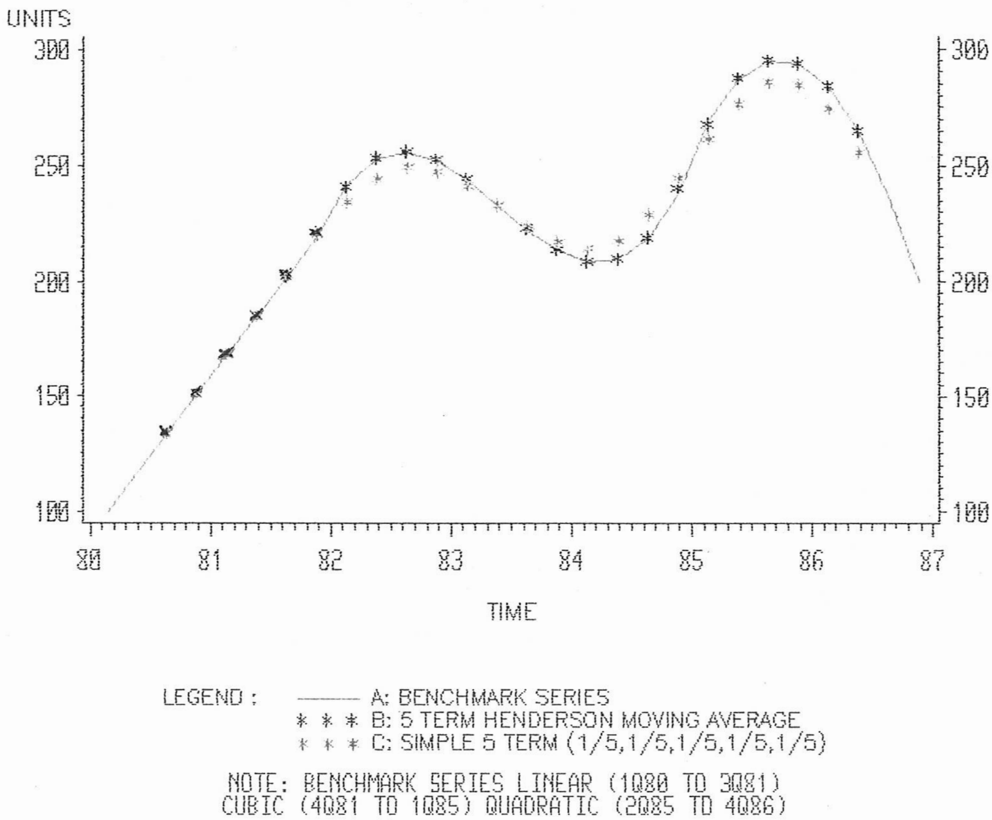
Specific properties of smoothing filters

Frequency decomposition

24. To appreciate the important and specific properties of the Henderson moving averages, and other moving averages or filters, the reader needs to understand that a time series may be thought of as the net result of the continual interaction of many cycles of different strength. In paragraph 3 it was mentioned that a time series could, in the simple case, be decomposed into three components - the seasonal pattern, the trend and the erratic residual. Each of these components covers a range of cycles. For example, the seasonal pattern for a monthly series may be represented by the annual cycle of 12 months long. It may also appear in the data as cycles of length 6, 4, 3, 2.4 and 2 months. These seasonal cycles occur respectively with the following frequency per year: 1, 2, 3, 4, 5 and 6. The trend or underlying direction of the series is usually thought of as a combination of the "business cycles", which have lengths ranging from about 3 to 7 years, and the even longer cycles contributing to the "secular trend". The residual component is made up of all the remaining cycles, its erratic appearance being consistent with the interplay of many short length cycles of various strengths.

GRAPH .9.

ARTIFICIAL SERIES

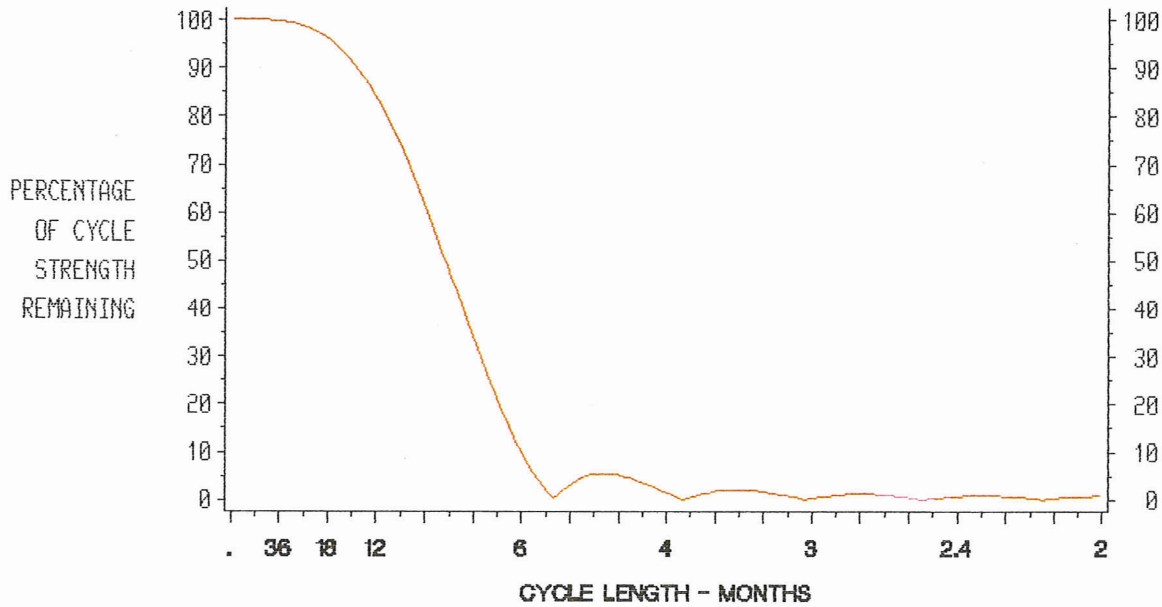


Damping properties

25. Given that a time series can be decomposed into various cyclical elements it is possible, as a result of one branch of statistics, to know in advance the impact that a particular moving average will have on the strength and timing of various cycles that may be in any time series. Graph. 10. below illustrates the cycle strength-dampening properties of the symmetric 13 term Henderson moving average. The horizontal axis displays the various cycle lengths ranging from two months long at the right hand end, to very long cycles at the left hand end. The vertical axis displays what percentage of a particular cycle strength remains after the moving average is applied to the data. For example, Graph. 10. shows that less than 6 per cent of the strength of any particular cycle shorter in length than 5.5 months remains in a series smoothed by a 13 term Henderson moving average. Cycles shorter than this length contribute significantly to the volatility of many series. It can also be seen from Graph. 10. that about 85 per cent of the strength of the fundamental seasonal cycle of 12 months would remain if the series being smoothed had not first been seasonally adjusted, thus removing this cycle. The other seasonal cycles of 6, 4, 3, 2.4 and 2 months long would, if not already adjusted for, have strengths respectively of 10, 2, 0, 0 and 0 per cent. It is for this reason that the 13 term Henderson moving average is never applied to data that contain fundamental seasonality, because the yearly cycle would remain. Graph. 10. also shows that cycles about 18 months long would remain with about 95 per cent of their strength. Because the symmetric 13 term Henderson moving average cannot filter out all or most of the strength of cycles shorter than the business cycles but longer than a year, such smoothed estimates are only loosely referred to as "trend" or "trend-cycle" estimates. It is important to note that, if *sampling errors* or *non-sampling errors* can be characterised by cycles in the 6 to 2 months range or thereabouts, the filtering process contributes to a substantial reduction of their presence in the smoothed series. Smoothing or filtering may consequently enhance the usefulness of the data in this regard.

GRAPH .10.

EFFECT OF THE 13 TERM HENDERSON MOVING AVERAGE ON CYCLES



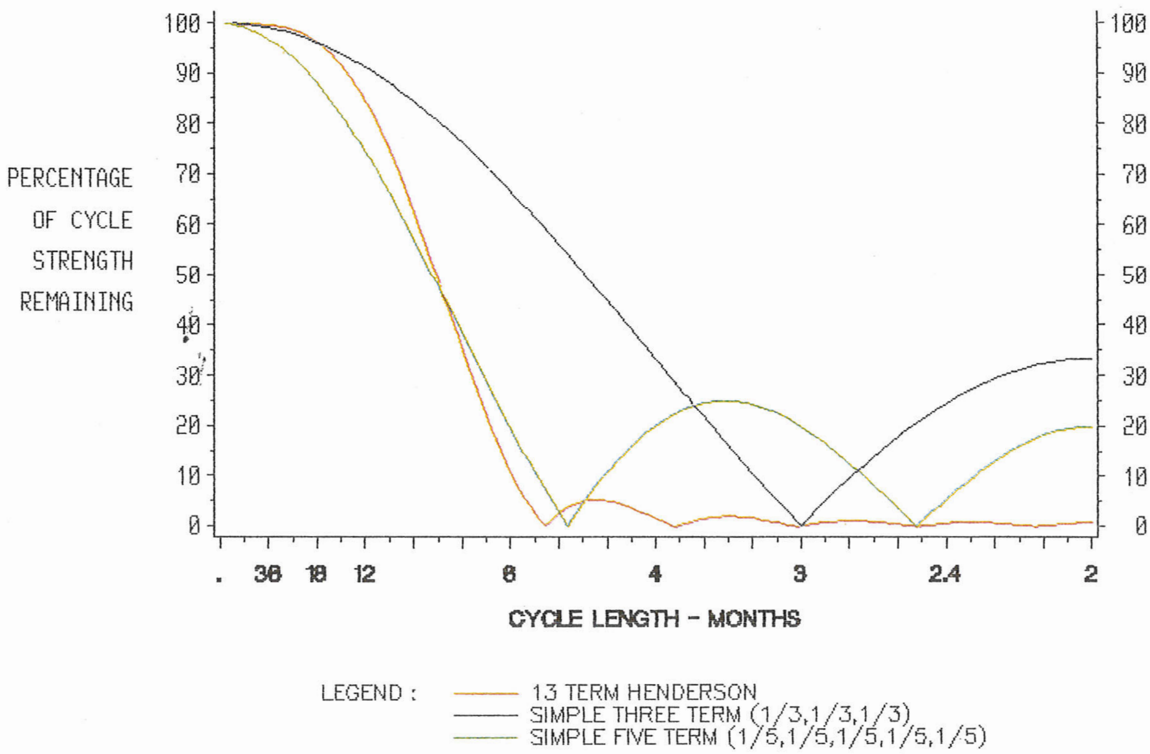
26. One practical advantage of smoothing seasonally adjusted series with a symmetric 13 term Henderson moving average is that if the seasonal adjustment process used has some deficiencies, such that there remains residual amounts of seasonality, trading-day or movable holiday variation in the adjusted data, the smoothing process will greatly dampen their presence. For example, less than 5 per cent of the strength of the residual trading-day cycles would remain, and less than 10 per cent of the residual seasonal cycles of 6 months length or shorter would remain in the smoothed seasonally adjusted data. The shorter seasonal cycles would be removed. The symmetric 13 term Henderson moving average would also greatly dampen any residual movable holiday cycle, such as the influence of Easter holidays moving from the month of April, where they normally fall, to the month of March. Another important feature of the smoothed estimates is that they are much more stable than the seasonally adjusted series from which they are derived. That is, although the seasonally adjusted series are subject to revision at each re-analysis, usually annually, the revisions to the smoothed estimates is very much smaller because of the averaging process. This aspect will be discussed in more detail below.

Comparative damping

27. For comparative purposes simple 3 term and 5 term moving averages are displayed with the symmetric non-simple 13 term Henderson moving average in Graph .11. below. The reason for this comparison is that many people employ these simple averages in one way or another to smooth the data. For instance, users of monthly data may look at "three months ended" seasonally adjusted data compared to previous three months. Such a procedure is identical to computing the movement measured three months apart in the seasonally adjusted series, smoothed by a simple symmetric 3 term moving average. Ironically, one month movements instead of one quarter of a year apart movements could be considered in the very same smoothed series, though the last current movement is still lost if time phase shift is avoided. It is clearly evident from Graph .11. that each of these moving average filters produce potentially different results from the seasonally adjusted data. For example, neither the simple three or simple five term moving averages can dampen the cycles shorter than six months as efficiently as the 13 term Henderson average, and the simple 3 term average allows more of the strength of cycles shorter than twelve months to pass than either of the others. Consequently the users of the simple 3 term and 5 term moving averages should assess whether their centered or off-centered use is providing the desired degree of filtering for the analysis at hand, remembering that off-centering introduces a time phase shift.

GRAPH .11.

EFFECT OF MOVING AVERAGES ON CYCLES



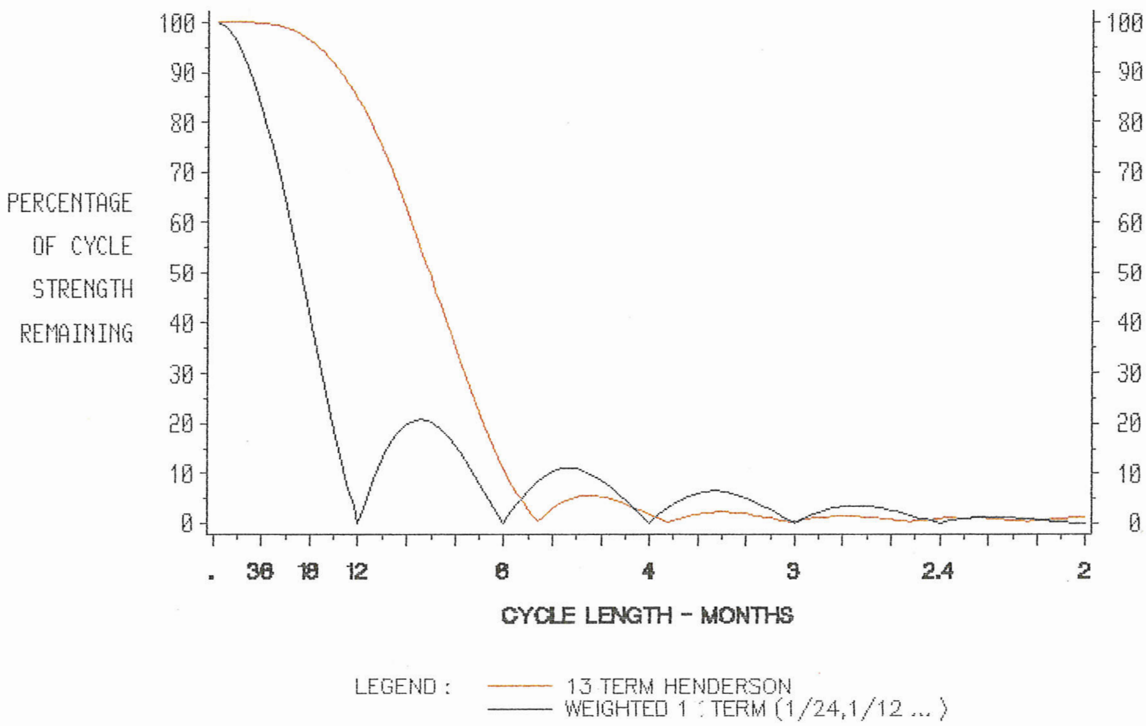
28. For further comparison the non-simple symmetric 13 term moving average 1/24, 1/12, . . , 1/12, 1/24 is compared to the symmetric 13 term Henderson moving average in Graph. 12. below. It should be noted that this filter is used by many analysts to perform crude seasonal adjustment and "trend" estimation. Again it can be seen that these moving averages differ in some important respects. For example, the non-simple 13 term average is seen to remove the seasonal cycles of 12, 6, 4, 3, 2.4 and 2 months length, whereas the 13 term Henderson doesn't. However, the former lets pass a greater amount of the strength of cycles whose length is 6 months or less but dampens also the cycles which are longer than 18 months.

The end-point problem

29. It is crucial for the reader to understand that different moving averages have different inherent properties with respect to damping and time phase shift. This understanding is vital because at the start and, more importantly, at the current end of the series the non-time phase shifting symmetric moving averages cannot be used directly. Consider applying a symmetric 13 term moving average to some data that end in September 1986. The last 13 consecutive monthly observations span from September 1985 to September 1986 inclusively. This span will give the last symmetric moving average value that can be directly calculated from the available data centered on March 1986 (the seventh term of the 13 month span). The last six months from April 1986 to September 1986 cannot be smoothed by the symmetric 13 term moving average because there are not sufficient observations available for the calculation. This aspect of using symmetric moving averages is known as the "end-point" problem. To produce results at the ends of the series, *surrogate* moving averages that approximate the properties of the desired symmetric moving average are employed.

GRAPH .12.

EFFECT OF MOVING AVERAGES ON CYCLES



Solutions — shorter Henderson averages?

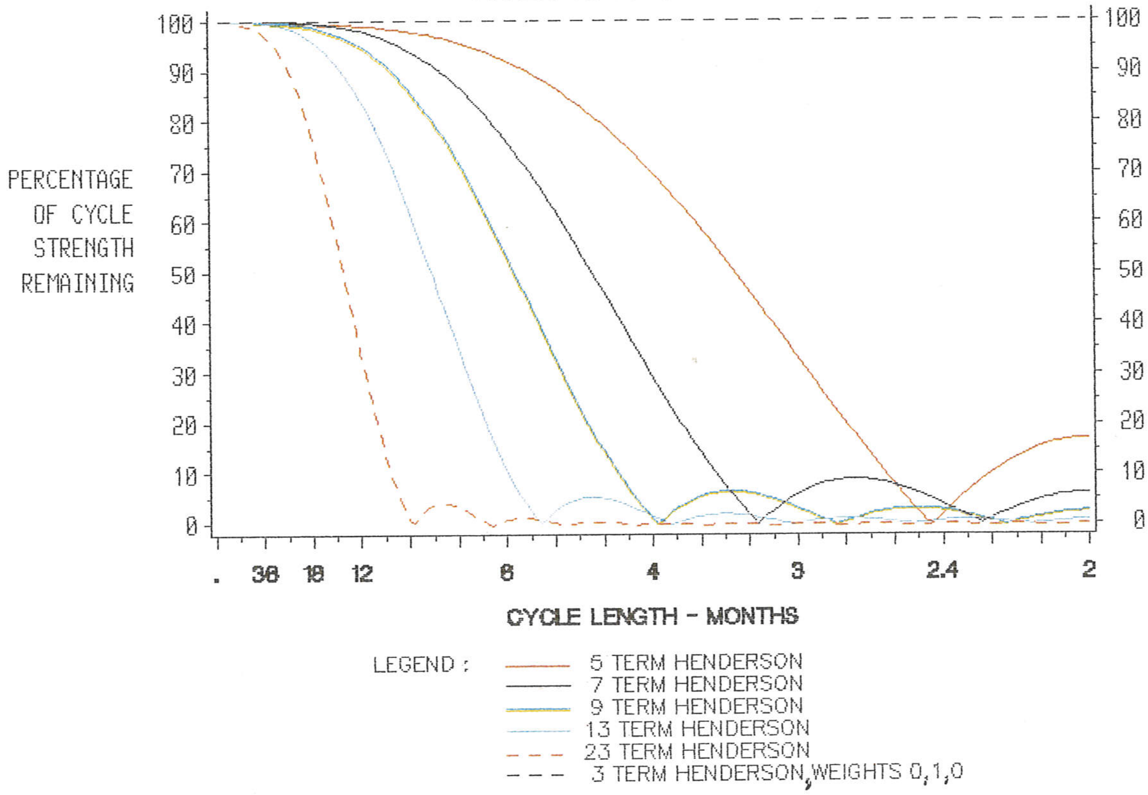
30. To overcome this end point problem one might consider using a collection of *progressively shorter symmetric moving averages.* For instance, if a symmetric 13 term Henderson moving average had been used to smooth the substantive part of the time series, one might consider using an 11 term Henderson to estimate the sixth last value, a 9 term Henderson to estimate the fifth last, a 7 term Henderson for the fourth last, etc. However, the second last value could not be smoothed because a 3 term Henderson moving average doesn't alter the data: it has the weighting pattern of 0.0, 100.0, 0.0 per cent. The last observation can't be smoothed either because there is no symmetric Henderson moving average available for just one observation. Further, the smoothing properties of the 11 to 5 term Henderson moving averages differ significantly from each other and the 13 term Henderson. Graph. 13. below illustrates these differences.It is clear that this option is not a satisfactory solution to the end point problem because it leads to inconsistent filtering characteristics at the topical end of the series where there is often the keenest interest.

Solutions — shorter simple averages?

31. Similar to the option considered above, one might contemplate using a collection of *progressively shorter simple moving averages,* with the symmetric 13 term Henderson moving average, for resolving the end point problem. For instance, using a simple 11 term moving average (non-Henderson) for the sixth last, a 9 term for the fifth last, etc, up to a simple 3 term moving average for the second last value. Again there is a problem at the very end of the series because it can't be smoothed with any symmetric moving average. There is also the important consideration of consistent filtering at the current/topical end of the series. Graph. 14. below illustrates how the simple symmetric moving averages considered above differ from the symmetric 13 term Henderson moving average in their filtering effects on the data, and from each other.

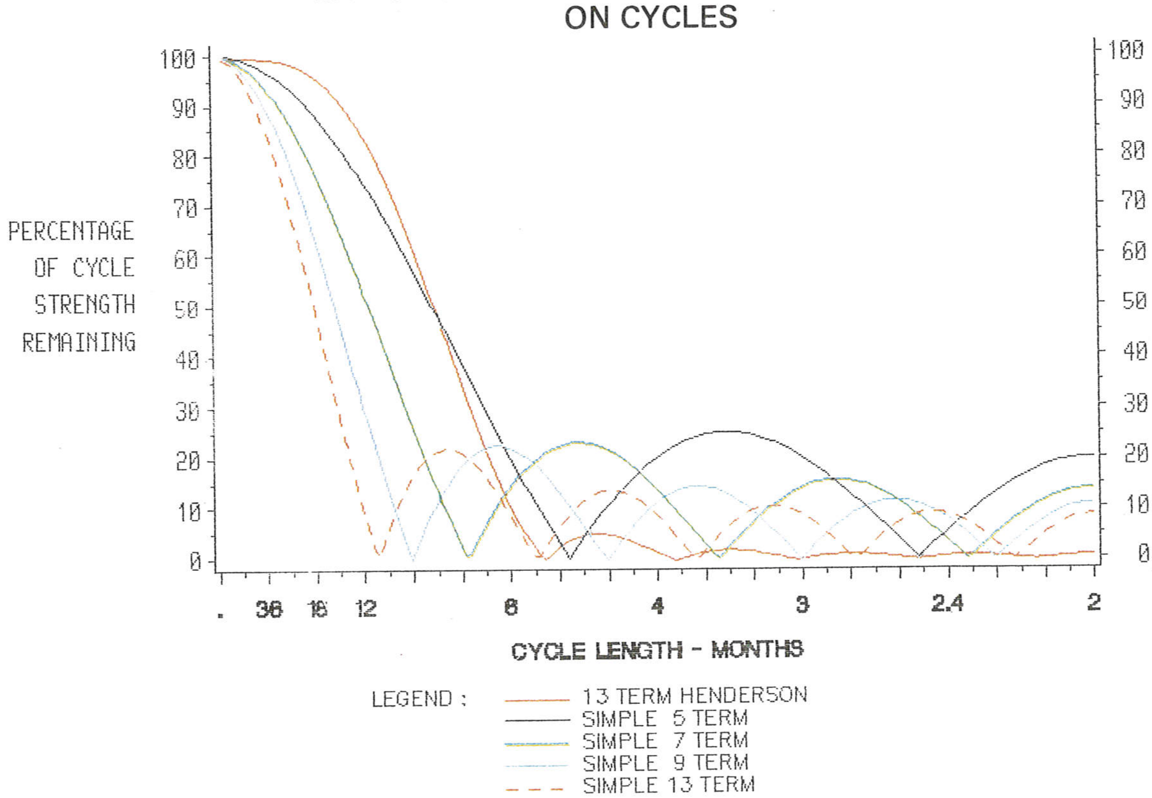
GRAPH .13.

EFFECT OF VARIOUS HENDERSON MOVING AVERAGES ON CYCLES



GRAPH .14.

EFFECT OF SYMMETRIC MOVING AVERAGES ON CYCLES

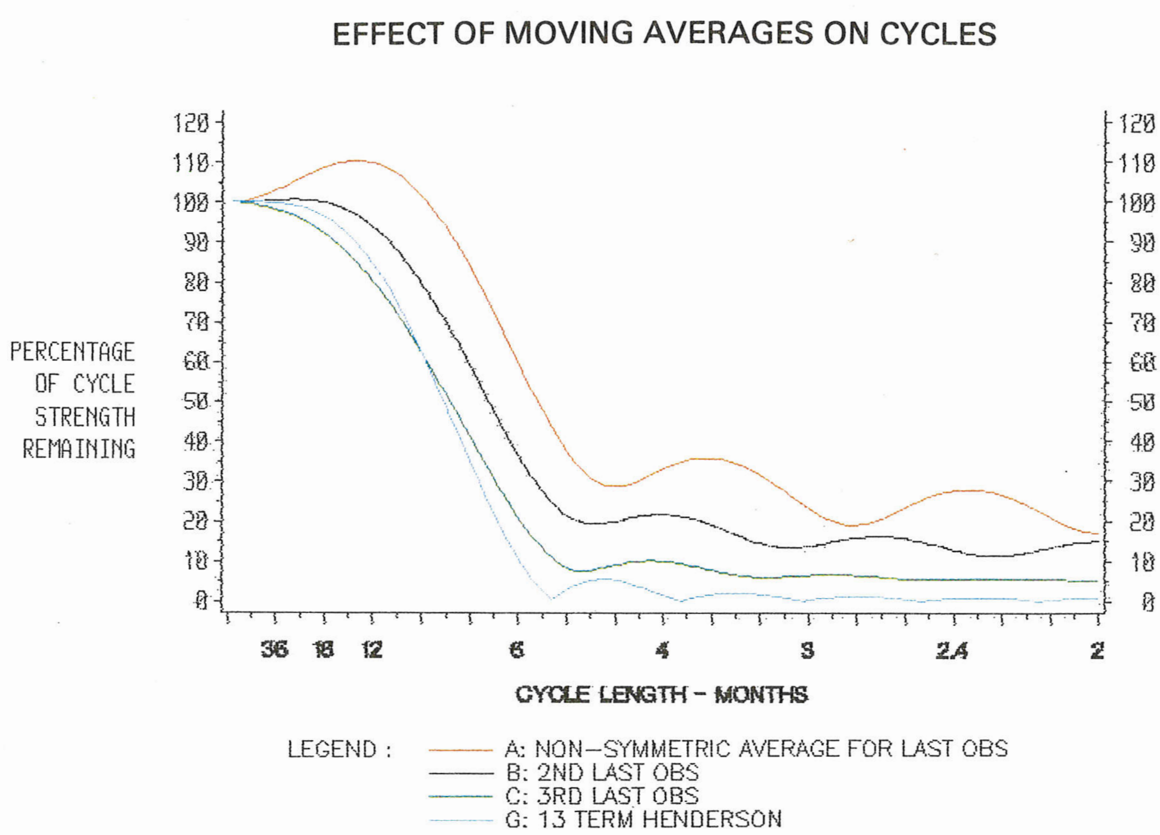


Solutions — surrogate moving averages?

32. One practical solution to the end point problem is to adopt a collection of *surrogate moving averages that are non-symmetric,* yet approximate the desired filtering properties of the symmetric moving average used over the substantive part of the time series. It should be remembered (refer to paragraph 18) that non-symmetric moving averages, however, cause time phase shifting to *varying degrees* over the range of cycles they are dampening. The aim, therefore, is to use a collection of *non-symmetric moving averages* that approximate very well the cycle dampening properties of the symmetric Henderson moving average, which have at the same time minimal time phase shifting properties. The characteristics of one group of such *surrogate* moving averages used presently by the Australian Bureau of Statistics are illustrated below in Graphs. 15. and .16.

33. In Graph .15. the cycle strength dampening properties of some of the *surrogate* moving averages used by the Bureau, are compared to the symmetric 13 term Henderson moving average. For the ease of presentation and clarity only the surrogate moving averages used for estimating the last three observations are graphed with the symmetric 13 term Henderson. The other surrogate moving averages used to estimate the sixth, fifth and fourth last values lie between and about the 13 term Henderson and the surrogate moving average (C). They are illustrated in Appendix B. It can be seen from Graph .15. that the non-symmetric moving average used to estimate the last (A) and second last (B) values of the series approximate the symmetric 13 term Henderson moving average less well than any of the other non-symmetric moving averages used to estimate smoothed values. However, for most practical purposes the non-symmetric moving averages used to estimate the sixth-, fifth- and fourth-last smoothed values are sufficiently good approximations to the symmetric 13 term Henderson to be regarded as equivalents with respect to cycle strength reduction, and the third-last (C) is a fair approximation.

GRAPH .15.

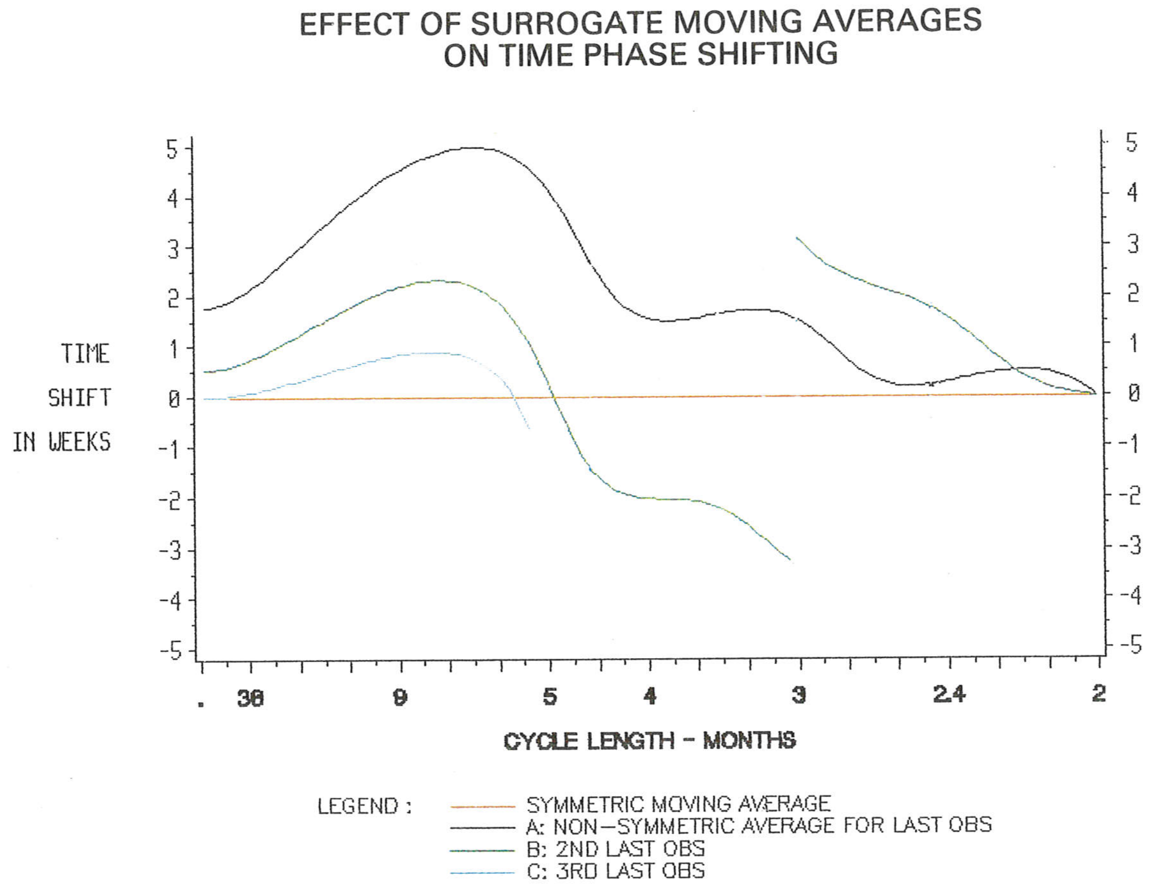


34. Illustrated in Graph .16. below are the time phase shifting effects of some of the non-symmetric moving averages used as surrogates for the symmetric 13 term Henderson moving average. For presentational ease only, the time phase shifts of cycles that could remain with at least ten percent of their strength are shown. It can be seen that the non-symmetric moving average (C) used for estimating the third last smoothed value does not displace cycles longer than five and a half months by more than one week. It is important to note that the long cycles that make up the trend behaviour are not significantly time phase shifted. When considering the non-symmetric moving average (A) used for estimating the last or recent smoothed value it can be seen that cycles of ten to five months long are time shifted at most five weeks; shorter cycles are shifted by much lesser amounts, while cycles longer than ten months are time phase shifted by about two to four weeks. When considering the time phase shifting effect of a moving average one should keep in perspective the strength that a particular time phase shifted cycle would have in the smoothed data; it may have a minimal contribution. It should be noted that the non-symmetric averages used for estimating the sixth-, fifth- and fourth-last smoothed values have only marginal time shifting effect on cycles remaining with more than ten percent of their strength.

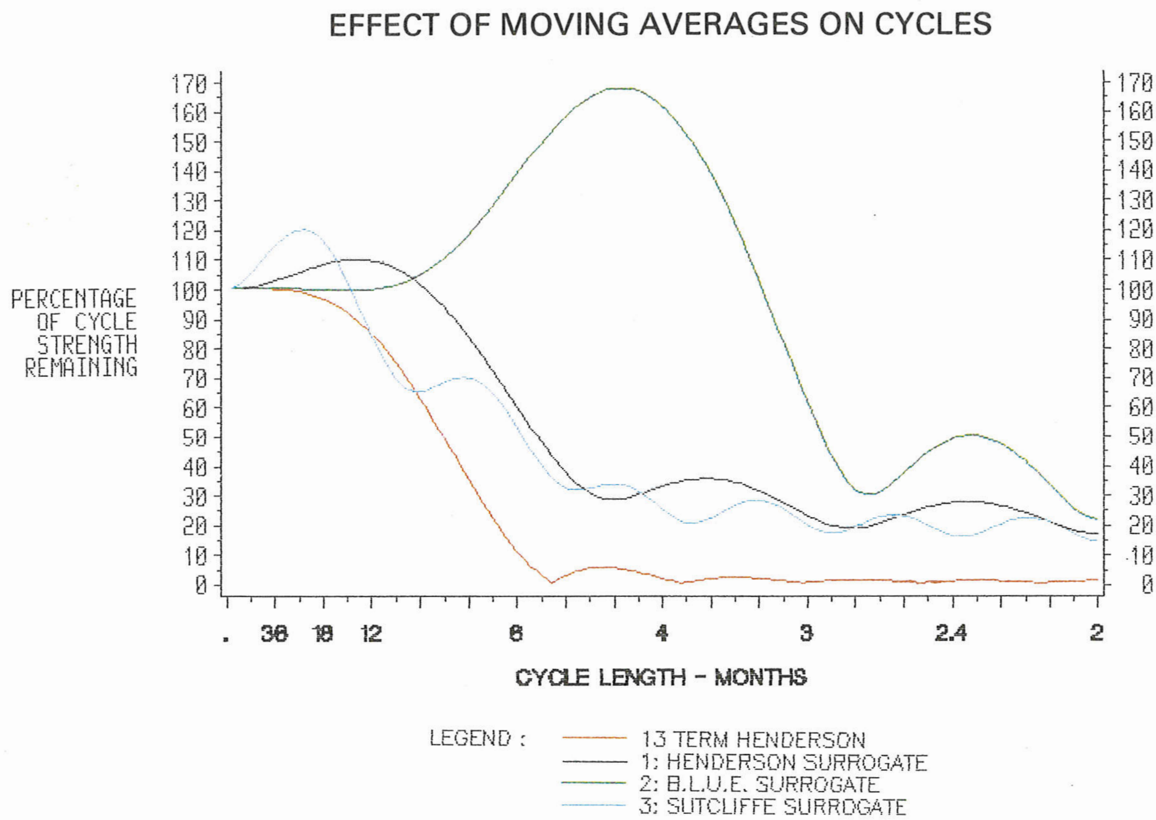
Trade-offs

35. There are a large number of non-symmetric moving averages that could be considered as alternative to the set described above, and presently used by the Australian Bureau of Statistics. For comparative purposes Graphs .17. and .18. illustrate the properties of just three non-symmetric moving averages that could be used to estimate the last or most recent smoothed value, with those of the symmetric 13 term Henderson moving average which they are attempting to approximate. The Graphs show the trade-off that must be considered when applying a surrogate non-symmetric moving average. For instance, the non-symmetric moving average (2) has distinctly different cycle strength reduction properties to the other non-symmetrics and Henderson average, but has generally less time phase shift effects, and in the latter sense is more similar to the Henderson average. On the other hand, the non-symmetric moving average (3) approximates the 13 term Henderson average slightly better than (1) as regards damping, but has slightly worse time phase shift characteristics for cycles greater than nine months. An improvement in one of the desired characteristics —damping or lack of time phase shift — sometimes can only be achieved at the expense of the other. The non-symmetric moving average (1) is presently used by the Australian Bureau of Statistics, whereas the other two are not. The non-symmetric moving average (2) is called the BLUE, and (3) the SUTCLIFFE.

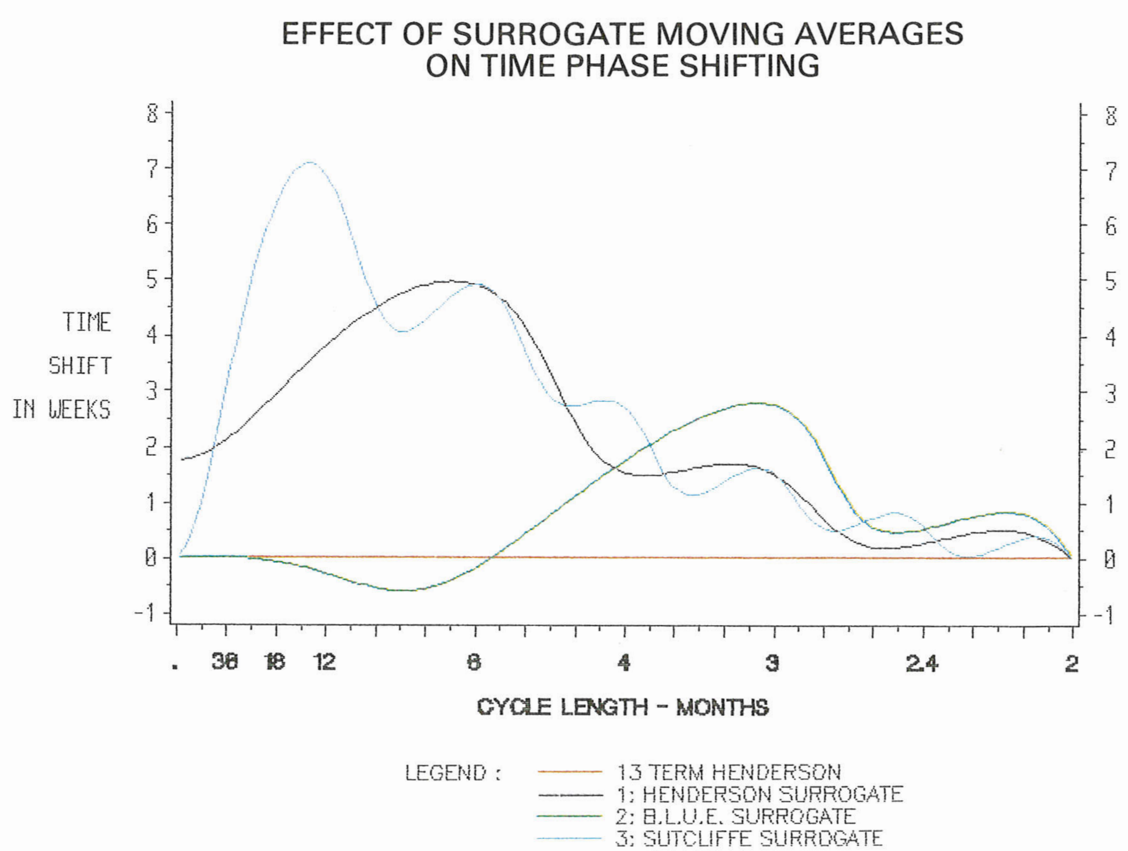
GRAPH .16.



GRAPH .17.



GRAPH .18.



Henderson weights

36. Above, the characteristics of some of the moving averages used by the Australian Bureau of Statistics have been illustrated. Below, in Table .3., the specific weighting patterns used for computing each monthly smoothed value are detailed: L for the last month, L-1 the last but one, L-2 the last but two, etc. In the bottom row of Table .3. (L-6, etc) the weighting pattern of the symmetric 13 term Henderson moving average can be seen; the weights are symmetric about the point whose smoothed value is being estimated, the seventh last observation (L-6 in this case). Next row up from the bottom (L-5) there is displayed the weighting pattern of the surrogate non-symmetric moving average used to estimate the sixth last (L-5) smoothed value. In the top row (L) the weighting pattern of the non-symmetric moving average used for estimating the last smoothed value appears. From Table .3. it can be seen that the non-symmetric moving averages become less symmetric about the time period they refer to (indicated by the diagonal bar across Table .3.) as they get shorter and approach the end of the series; the shortest moving average is in fact one-sided. The weighting patterns of these non-symmetric moving averages appear in Charts .1. to .6. of Graph .19. below. The symmetric 13 term Henderson moving average appears in Graph .7. above.

TABLE .3.

13 term Henderson moving average and the surrogate non-symmetric end point moving averages.

Smoothed value for month	*Percentage of seasonally adjusted value combined with other months, in month:* L-12	L-11	L-10	L-9	L-8	L-7	L-6	L-5	L-4	L-3	L-2	L-1	L
L							-9.2	-5.8	1.2	12.0	24.4	35.3	42.1
L-1						-4.3	-3.8	0.2	8.0	17.4	25.4	29.2	27.9
L-2					-1.6	-2.5	0.3	6.8	14.9	21.6	24.1	21.6	14.8
L-3				-0.9	-2.2	0.4	6.6	14.5	20.8	23.0	20.1	13.1	4.6
L-4			-1.1	-2.2	0.3	6.7	14.5	21.0	23.5	20.5	13.6	5.0	-1.8
L-5		-1.7	-2.5	0.1	6.6	14.7	21.3	23.8	21.2	14.4	6.1	-0.6	-3.4
L-6, etc	-1.9	-2.8	0	6.6	14.7	21.4	24.0	21.4	14.7	6.6	0	-2.8	-1.9

Constancy

37. From Table .3. above two important features are evident. It should be emphasized that the weighting pattern of the Henderson moving average and its surrogate moving averages does not vary:

(1) according to the different time series they are being applied to

or

(2) according to the time in history that they are being applied.

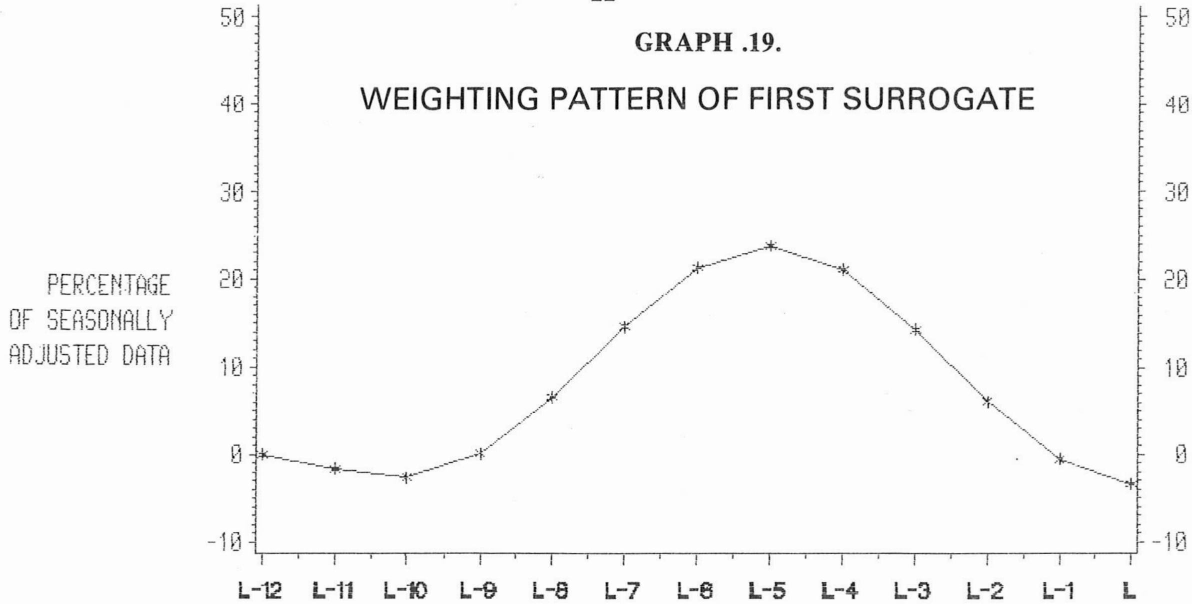
That is, the symmetric 13 term Henderson moving average is the same regardless of whether it is applied to unemployed persons or building approvals, and it is also the same regardless of whether the smoothing is being performed through 1979, 1983 or 1985, etc.

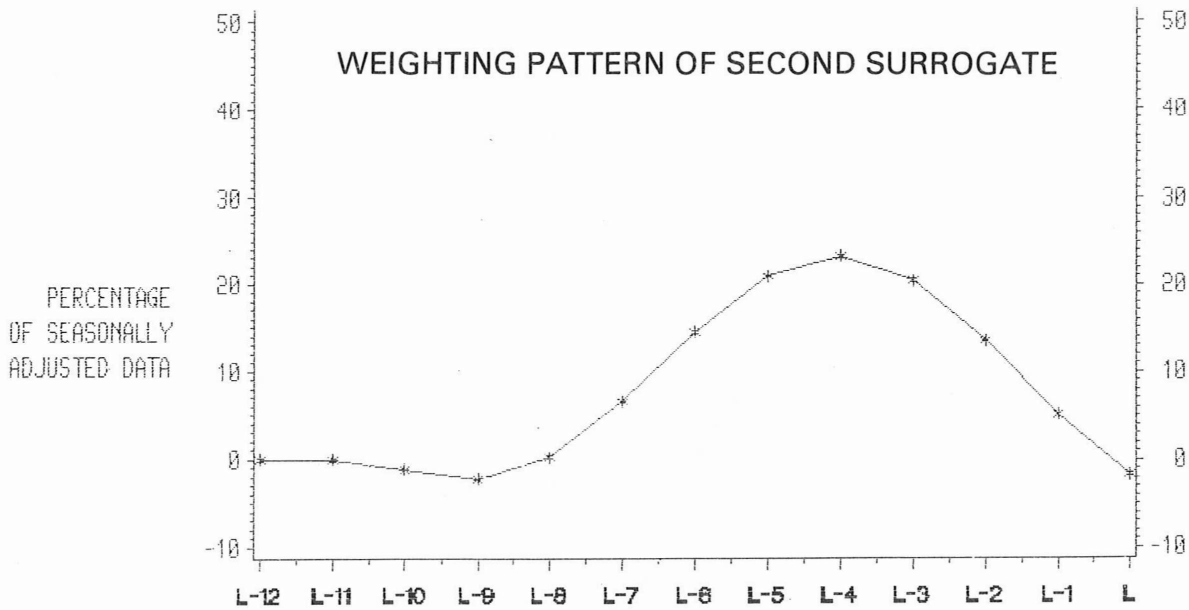
Use and interpretation of trend estimates

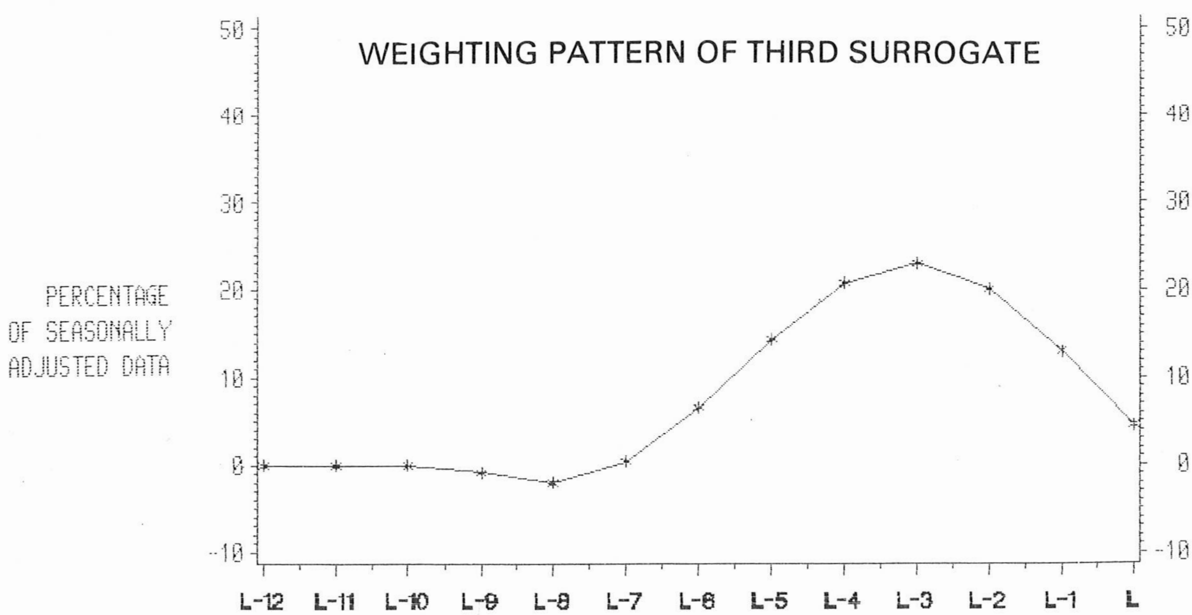
Revision

38. As subsequent monthly data become available, it is possible to apply the symmetric 13 term Henderson moving average to periods that have been previously smoothed by the various surrogate non-symmetric moving averages. For instance, with the addition of six months data an observation derived initially from the shortest non-symmetric moving average may now be replaced/revised by the estimate obtained from the symmetric 13 term Henderson. Consequently, as additional data become available the last six observations are subject to revision as progressively less non-symmetric moving averages are applied. However, as indicated above in Graphs .15. and .16., it is only the three least symmetric moving averages that approximate least well the symmetric 13 term Henderson moving average. Therefore, the largest revisions to a particular month should occur at most three times, getting smaller each time. For series that are relatively less erratic the extent of the revision would be expected to be smaller. Whether any of these revisions are "significant" will depend on the particular circumstances in which these indicators are being used.

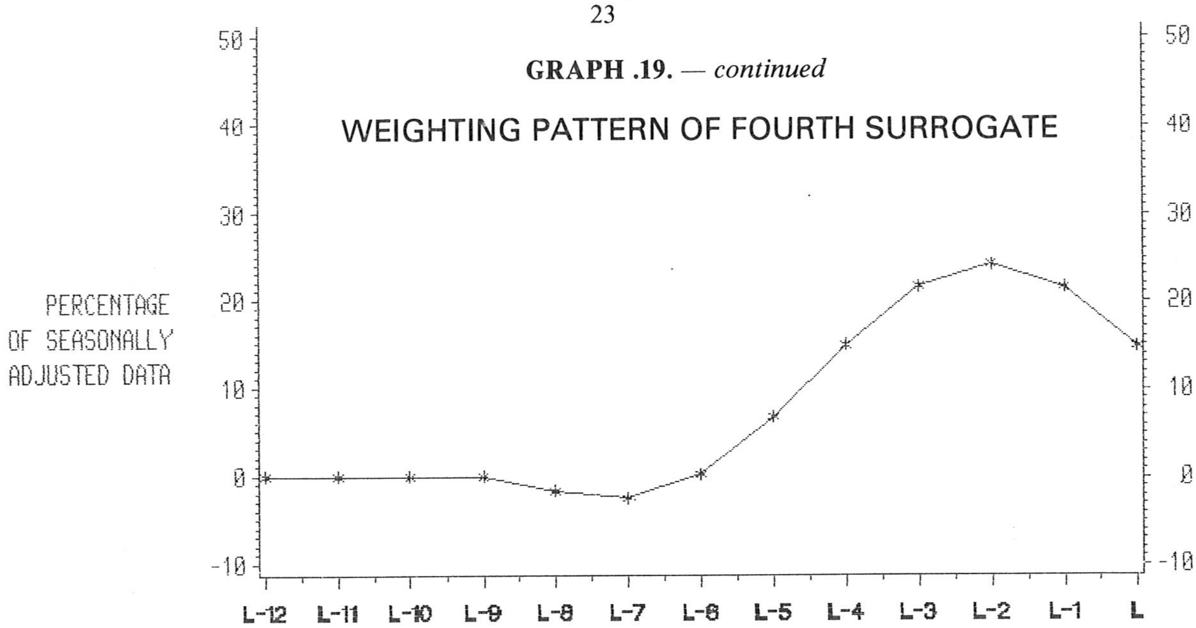
GRAPH .19.

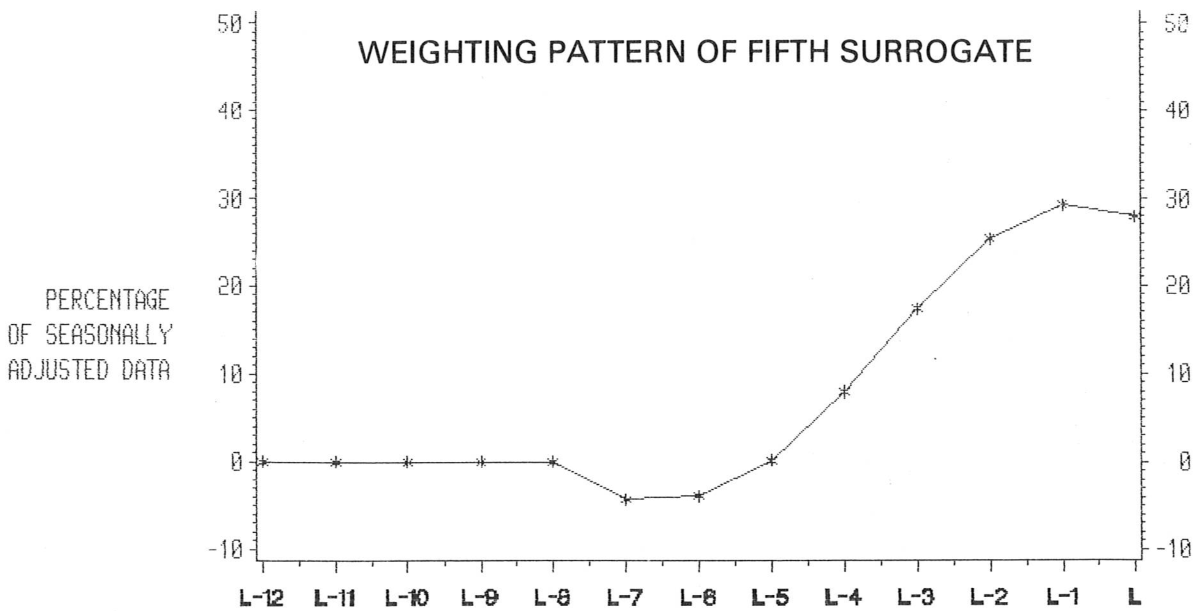

WEIGHTING PATTERN OF FIRST SURROGATE
PERCENTAGE OF SEASONALLY ADJUSTED DATA
50
40
30
20
10
0
-10
L-12 L-11 L-10 L-9 L-8 L-7 L-6 L-5 L-4 L-3 L-2 L-1 L

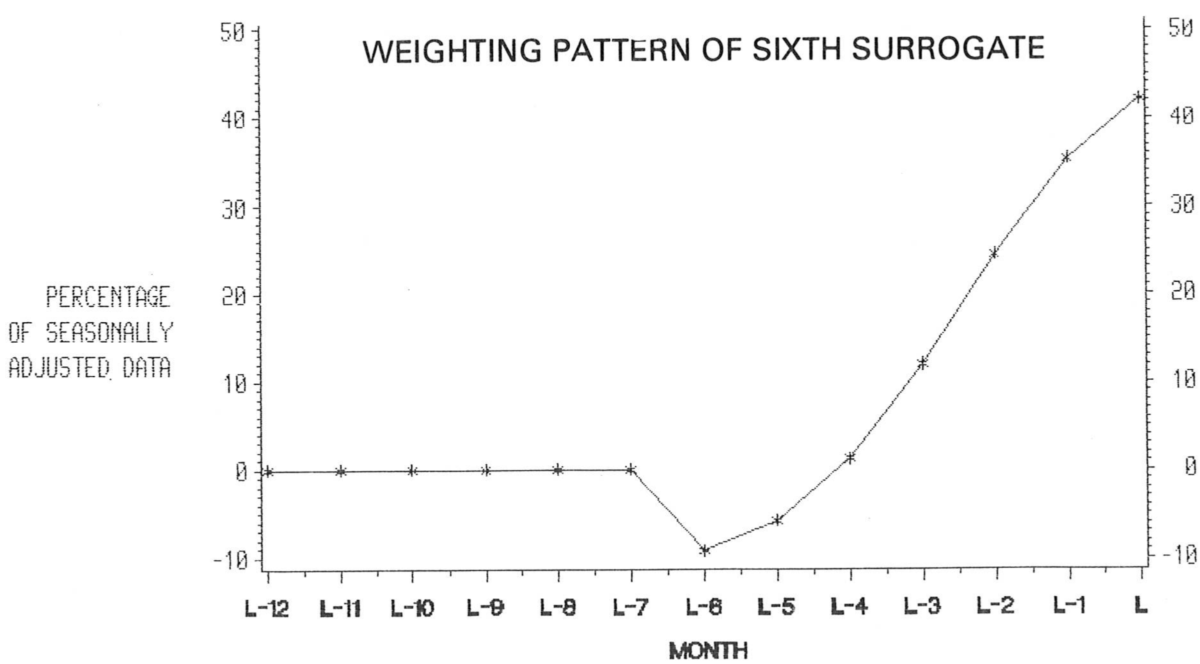

WEIGHTING PATTERN OF SECOND SURROGATE
PERCENTAGE OF SEASONALLY ADJUSTED DATA
50
40
30
20
10
0
-10
L-12 L-11 L-10 L-9 L-8 L-7 L-6 L-5 L-4 L-3 L-2 L-1 L


WEIGHTING PATTERN OF THIRD SURROGATE
PERCENTAGE OF SEASONALLY ADJUSTED DATA
50
40
30
20
10
0
-10
L-12 L-11 L-10 L-9 L-8 L-7 L-6 L-5 L-4 L-3 L-2 L-1 L
MONTH

GRAPH .19. — *continued*







Revision assessment

39. One means of gaining an appreciation of the extent of revisions is to simulate the performance of the smoothing procedure about an important turning-point in a major socioeconomic indicator. As a case study the smoothing of seasonally adjusted unemployed has been simulated through 1983. These simulations involve seasonally adjusting the data up to January 1983, then using the seasonal adjustment factors to produce seasonally adjusted values for the remainder of 1983 which are in turn smoothed progressively, as might have happened in 1983. The performance of the 1983 smoothed series may then be judged against the smoothed series obtained by utilising all the information presently available. This latter benchmark series represents the stable or historic smoothed series.

40. Table .4. below records the smoothed seasonally adjusted results. The value for January 1983 of 642.8 that appears in the top left hand corner of the table represents the first smoothed estimate; it has been obtained by applying the one-sided non-symmetric surrogate moving average to the seasonally adjusted data available up to January 1983. In the next row down the January value of 648.2 is the first revision of the smoothed data; it has been obtained by applying the second most non-symmetric surrogate moving average (refer to Table .3.) to the seasonally adjusted data that is now available to February 1983. In the same row the February value of 667.8 is the first estimate. It can be seen from Table .4. that after the sixth revision the smoothed values are no longer revised. This is because from this point onwards the same symmetric 13 term Henderson moving average weights are applied. A revision to these values will now only take place if the original data is changed, thereby leading to a revision in the seasonally adjusted data being smoothed, or the seasonally adjusted data is revised at the next (annual) reanalysis.

TABLE .4.

TOTAL UNEMPLOYED PERSONS

		1983											
Period		*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*Jun.*	*Jul.*	*Aug*	*Sep.*	*Oct.*	*Nov.*	*Dec.*
JAN. 1983		642.82											
FEB.	B	648.24	667.82										
MAR.		650.63	673.11	690.23									
APR.		651.22	673.68	693.83	708.84								
MAY		650.75	673.73	693.62	711.41	725.70							
JUN.		652.45	673.87	692.43	707.76	720.23	728.98		A				
JUL.		653.27	675.25	692.50	707.28	718.44	726.94	732.36					
AUG.		653.27	676.24	694.01	707.48	717.56	723.82	728.09	729.52				
SEP.		653.27	676.24	694.68	708.38	717.60	723.48	727.08	730.03	731.60			
OCT.		653.27	676.24	694.68	709.71	719.75	724.19	724.95	723.72	721.41	718.06		
NOV.		653.27	676.24	694.68	709.71	721.07	725.32	725.81	721.71	715.79	708.65	700.97	
DEC. 1983		653.27	676.24	694.68	709.71	721.07	728.13	728.71	723.11	712.64	699.25	684.14	669.63

Publication/revision policy options

41. It can be seen from Table .4. that there are many estimates to consider for publication. The issue is: "What is a reasonable revision policy?". For instance, one policy is *not to revise any of the first estimated smoothed values* until the annual reanalysis of the seasonally adjusted data. The application of this policy would mean that the smoothed results, which are often the subject of the keenest interest because they are at the topical/current end of the data, are for a period of a year based on the surrogate non-symmetric moving average that is known to approximate least well the desired features of the symmetric 13 term Henderson moving average with regard to cycle dampening and no time phase shifting. As will be seen below, this revision policy could lead to the timing of important turning points not being detected correctly for some period. This policy involves publishing monthly all the first estimates that appear on the first diagonal (A) of Table .4. The month to month actual movements of such smoothed estimates are recorded in Column 1 of Table .5. below.

TABLE .5.

Month to month changes in smoothed seasonally adjusted series.

Period	Col. 1.	Col. 2.	Col. 3.	Col. 4.
FEB. 1983	25.0	19.6	22.5	19.9
MAR.	22.4	17.1	19.9	14.9
APR.	18.6	15.0	15.3	12.1
MAY.	16.9	14.3	11.2	10.2
JUN.	3.3	8.8	6.3	7.1
JUL.	3.4	5.4	3.6	2.2
AUG.	-2.8	1.4	-1.2	-3.6
SEP.	+2.1	1.6	-5.9	-8.1
OCT.	-17.1	-3.4	-13.4	-11.8
NOV.	-17.1	-7.7	n.a.	-12.5
DEC. 1983	-31.3	-14.5	n.a.	-11.3

42. Another revision policy is to *publish the first revision only* of the smoothed series, and no more until the next annual reanalysis of the seasonally adjusted series. This policy is similar to the one above in that it still involves reliance upon the poorer approximating surrogate moving averages for a period of a year where interest in reliable estimates of trend behaviour is keenest. This policy also involves the risk that the timing of turning-points will be delayed. This policy involves publishing monthly the data appearing on the "step path" (B) marked on Table .4. The month to month actual movements of such smoothed estimates are recorded in Column 2 of Table .5.

43. A further revision policy is to *publish all consequential revisions* that occur as the desired symmetric 13 term Henderson moving average is progressively applied. This policy involves publishing each month a subsequent row of the smoothed values appearing in Table .4. If this policy is followed it can be seen that the third estimate of the month to month actual changes shows that a turning-point has occurred between July and August, as does the benchmark stable smoothed series, columns 3 and 4 respectively in Table .5. Subsequent revisions do not alter this timing. That is, under this policy users of this data would have had a reliable indication of the turning-point timing (between July and August 1983) when the October 1983 figure was first published. In contrast, the first revision policy considered above would have led users to have perceived the timing of the turning-point as being between September and October, two months later, and this perception would not be amended until the next annual reanalysis of the adjusted data. In this case study the next annual reanalysis was scheduled for January 1984. That is, under this policy users would not be provided with an indication that the turning-point is between July and August 1983 until January 1984. In some circumstances it is possible for this error period to be longer, the next annual reanalysis being later than January 1984. Similarly the second revision policy discussed above can cause problems, delaying the recognition of the timing of turning-points also.

ABS practice for minimising delayed recognition of turning-points

44. To avoid this delayed recognition of turning-point timing the Australian Bureau of Statistics publishes all revisions to its smoothed seasonally adjusted estimates. Experience to date indicates, however, that generally the third estimate of change in the smoothed series is a reliable guide to the timing of turning-points. This aspect is perhaps not surprising when it is recognised that the third estimate of movement involves the fourth and third estimates of the smoothed months being considered. For instance, the third estimate of movement between smoothed July and August 1983 values discussed above, is determined by the fourth estimate of July and the third for August. It will be recalled that the fourth estimate is determined by the fourth least non-symmetric 13 term Henderson moving average, and the third least non-symmetric, which generally is a fair approximation.

Interpretation of provisional estimates

45. In Graph .20. below the subsequent estimates of the smoothed series are plotted about the stable estimate of the July-August 1983 turning-point. It should be noted that while the correct timing of the turning point was not detected until data for October 1983 became available, there was nevertheless a dramatic indication of a significant slow down in the rate of trend increase preceding the turning point. This information was not so clearly evident from the very seasonal and irregular original data, or the irregular seasonally adjusted data (refer to Graph .21. below). Consequently, if the user of the smoothed data had anecdotal or other information concerning the socioeconomic behaviour, these significant changes in trend direction may have been sufficient warning of an imminent turning-point.

Assessment against implied irregularity

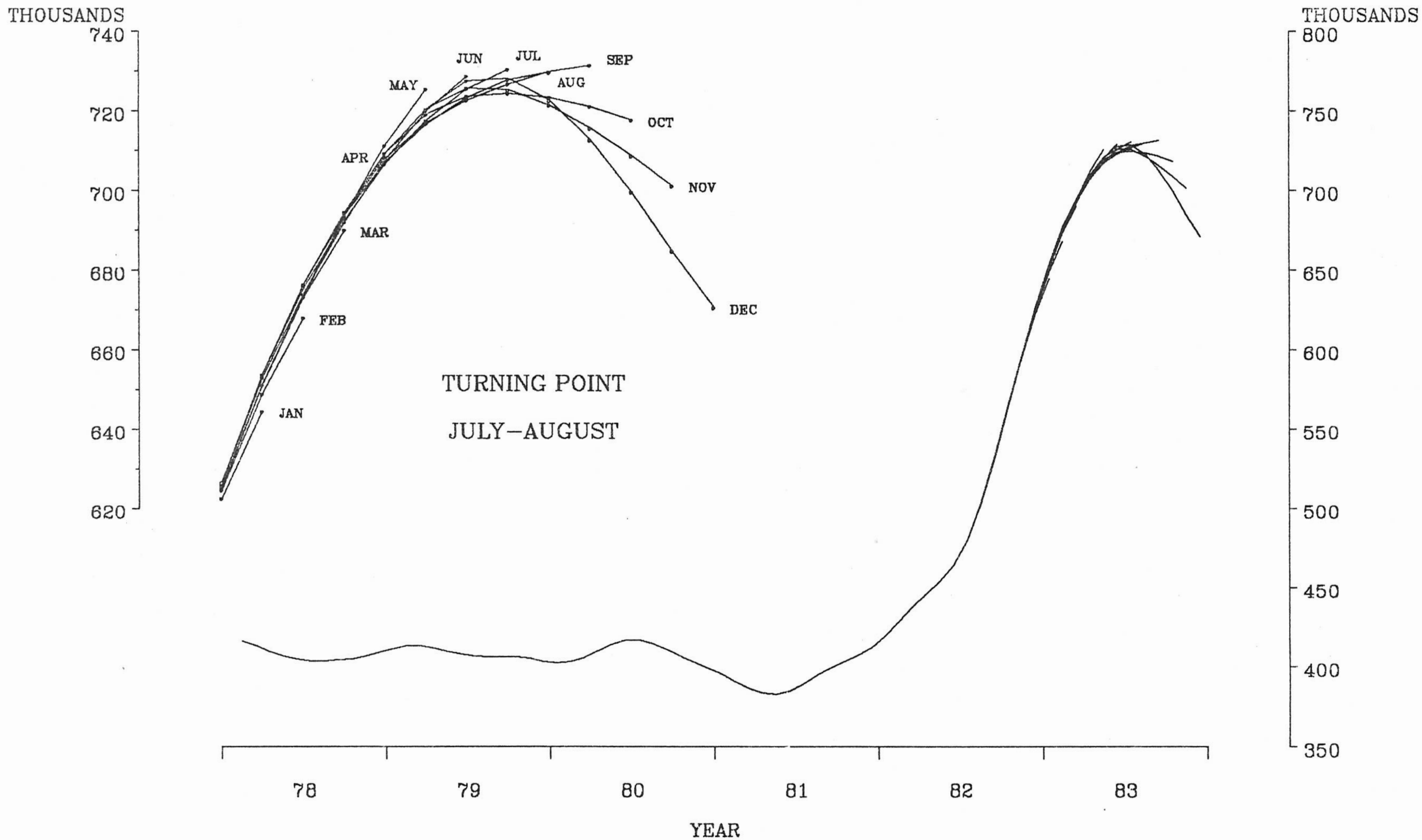
46. It is evident from the above discussion that the last couple of smoothed estimates published are the most provisional and cannot be heavily relied upon in their own right to provide indications of trend behaviour. To assist users at the current end of the series, however, the Australian Bureau of Statistics generally graphs and tables the smoothed seasonally adjusted estimates with the seasonally adjusted series. The reason for this practice is to enable the users to discern the relative magnitude and direction of the residual differences between the two series, the difference being an estimate of the current irregular influences. The user is then able to contrast these estimates of irregularity with his/her own knowledge or anecdotal information of the erratic influences in the present socioeconomic activity. If users believe that the current irregular is larger or smaller, up or down relative to what the Bureau has provided, they may amend the Bureau's provisional estimate of the smoothed series. In this regard, contrasting the smoothed series with the original series is not as helpful. As discussed earlier the difference between the smoothed data and the original series is an estimate of the combined effect of evolving seasonality, trading-day patterns, movable holiday influences and the irregular. Invariably the everyday user of the data will not have a fair idea of the magnitude and directional role of all these factors at each point of time.

Simple sensitivity analysis

47. Simple sensitivity analysis can be of further assistance to the user of provisional smoothed estimates. In general this analysis involves the user making a decision as to what degree of revision to the current estimate, either up, down or both, would be regarded as implying a distinctly different trend behaviour than presently shown by the smoothed series. That extent of revision is then fed into a formula to determine a seasonally adjusted value for the forthcoming month. The user then makes a subjective judgement as to whether this futuristic seasonally adjusted value is likely to be attained given the history of the seasonally adjusted series and the present socioeconomic circumstances. Below, this simple analysis is illustrated with respect to smoothed estimates of unemployed persons.

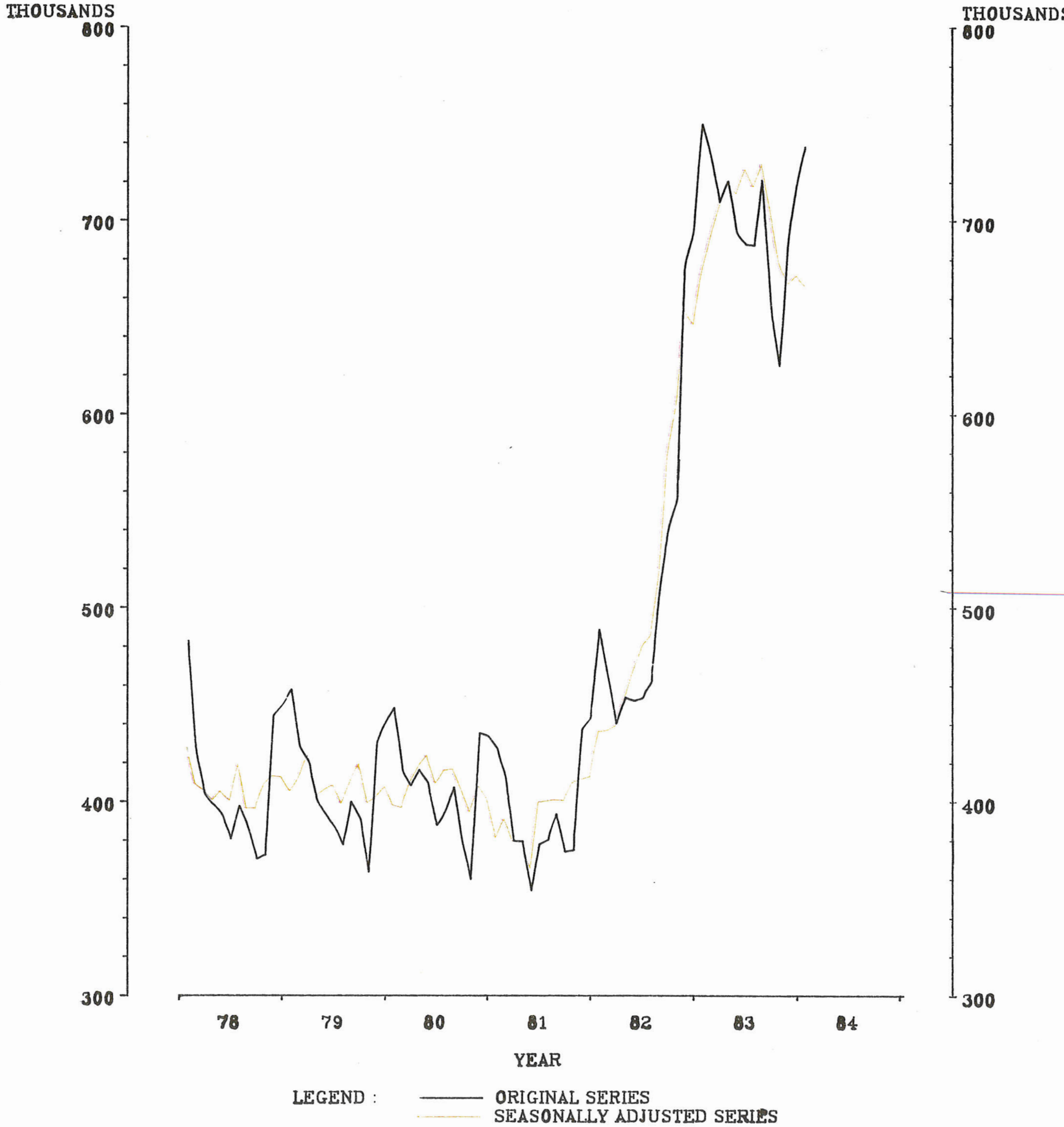
GRAPH .20.

TOTAL UNEMPLOYED PERSONS
SMOOTHED ADJUSTED SERIES



GRAPH .21.

TOTAL UNEMPLOYED PERSONS
ORIGINAL AND SEASONALLY ADJUSTED SERIES



48. In Graph .22. below the unemployed persons series is shown seasonally adjusted and smoothed up to March 1986. The questions of interest may be:

(1) whether the prima facie trough centered about November 1985 is really a trough and not subsequently going to be revised into a point of inflexion or temporary plateau, as appears in the smoothed series in early 1985;

(2) whether the trough will become as sharp as the May 1981 trough;

(3) whether the present sharpness of the trough will be essentially unaffected.

In the first case the current smoothed estimate would need to be revised from its present value of 593.1 to 582.4. This degree of revision will occur if the next seasonally adjusted figure is 554.7 (refer to Appendix C for the calculation,) That is, if the next seasonally adjusted figure was 554.7 or below, the present trough about November 1985 would be revised out of the smoothed series. In Case 2 the current smoothed value needs to be revised to 612.4 or above. This will occur if the subsequent seasonally adjusted value is 623.8 or above. In Case 3 no significant revision takes place if the subsequent seasonally adjusted figure is 593.0, or thereabouts. With reference to the previous history of the seasonally adjusted series and the readers own awareness of present economic conditions, he/she could decide which of the cases considered above are the more likely to eventuate.

Clipping smoothed series

49. While the simple sensitivity analysis described above is crude and looks at only part of the overall revision scenario, it is relatively easy for the user to employ and it does give some users a feel for the reasonableness or otherwise of the most current and provisional estimate of the smoothed series. In some instances, however, the provisional estimates at the current end of the series may undergo excessive revision and initially be very misleading. Whether this is so depends largely on the extent of the irregularity in the series. In the case of the unemployed persons series the irregular component varies by about 2 per cent (average month to month percentage change without regard to sign) and generally contributes to about 16 per cent of the monthly variation in the original data. This is in comparison to the trend which contributes to about 5.5 per cent of the original variation. In these circumstances the provisional smoothed estimates still tend to be useful and are therefore published by the Australian Bureau of Statistics with only some qualifications concerning their reliability at the end of the series. However, in a series like the value of nonresidential building approvals, the irregular component varies monthly by about 18 per cent (average month to month percentage change without regard to sign) and generally contributes to about 69 per cent of the monthly variation in the original data. Its trend component on the other hand contributes to only about 0.5 per cent of the original series variation. In this case the last three smoothed estimates obtained from the surrogate non-symmetric moving averages can be quite misleading because of large revisions, as illustrated below.

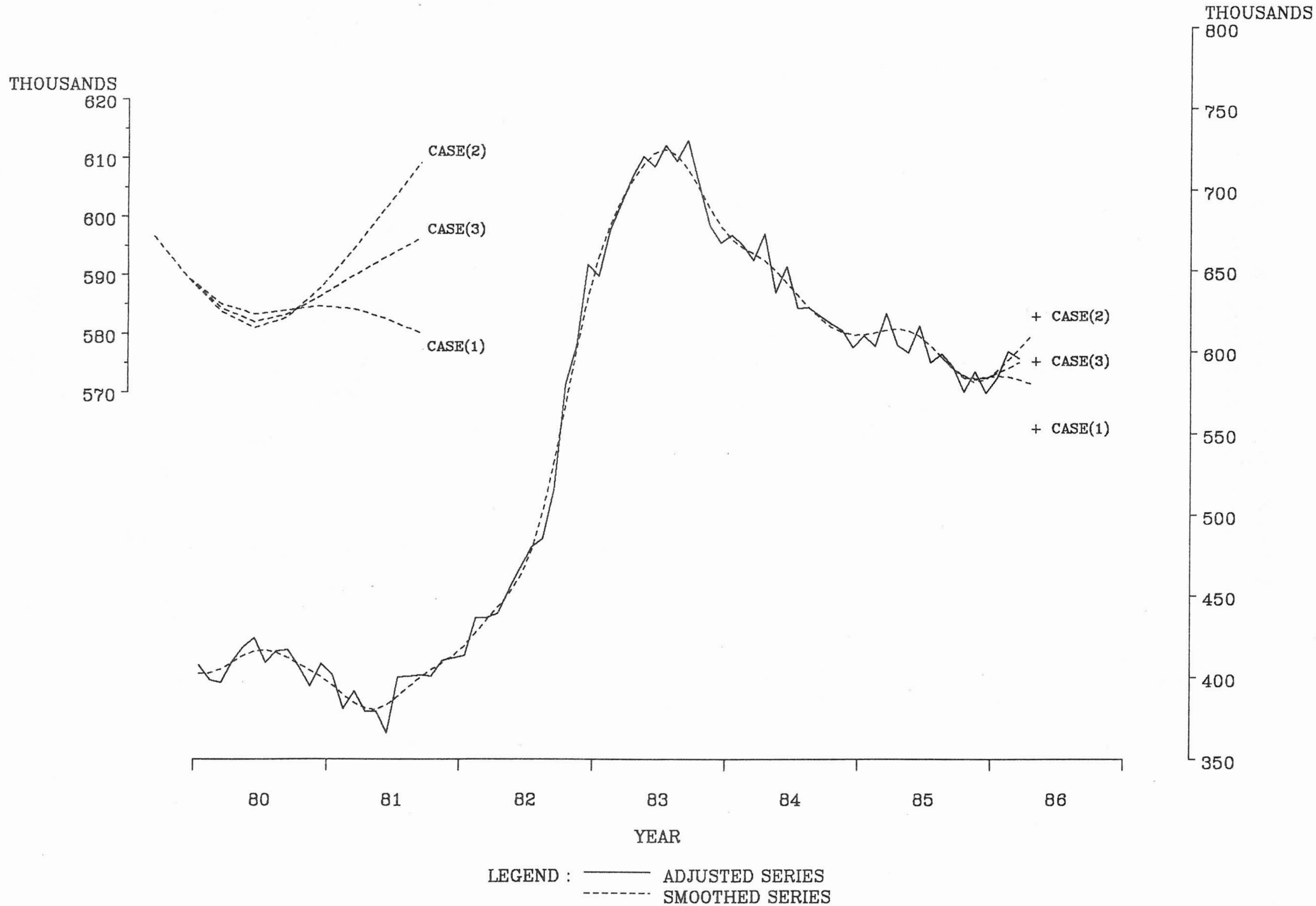
50. In Graph .23. below the results of progressively smoothing nonresidential building approvals through 1981 are illustrated. These smoothed seasonally adjusted series (1) to (12) are compared with the stable benchmark turning-point that peaked between September and October. As can be seen from Graph .23. there are some very large revisions to the direction of these early trend indicators. For instance, the first trend estimate for September is revised downwards by relatively large amounts in October and November. However, if each set of smoothed series has the three most current observations removed or "clipped" from the series, (1a) to (12a), it can be seen in Graph .24. that the results are not subject to such excessive revision, and consequently are not misleading. But this degree of reliability has been obtained at the cost of some timeliness. Nevertheless, where a series is so erratic it is not possible to discern with reasonable confidence the present trend direction. Consequently the Australian Bureau of Statistics warns users of this situation and clips the series at the current end (one, two or three months), in accordance with the general volatility observed in the original data.

Trend estimate stability

51. The example above shows that the Henderson trend estimates are relatively stable and generally robust, even when being derived from highly volatile series. What is of interest is how stable these estimates are relative to the seasonally adjusted data after a reanalysis, usually once a year, to incorporate the additional data and subject information with the refinement of the seasonal and trading-day adjustment factors. Experience to date indicates that the revision to the percentage movements of the trend series is very much smaller than those of the seasonally adjusted movements. For example, revisions to movements for Total Monthly Retail Sales have ranged between ± 0.1 percentage points for the trend and ± 0.6 for the seasonally adjusted series; for Cars and Station Wagons Registrations the revisions to trend and seasonally adjusted movements have been ± 0.5 and ± 5.2 respectively. This degree of stability should not be surprising since the filtering process is dampening much of the estimation error associated with the recent estimates of the seasonally adjusted series. Further, the difference between the degree of revision is expected to be larger the more erratic the series is.

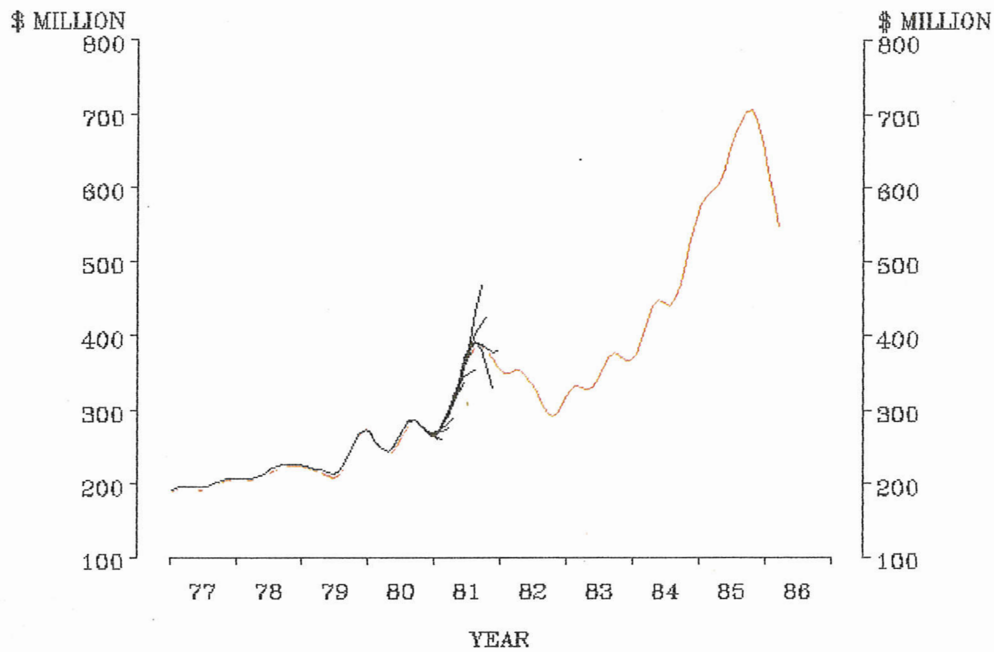
GRAPH .22.

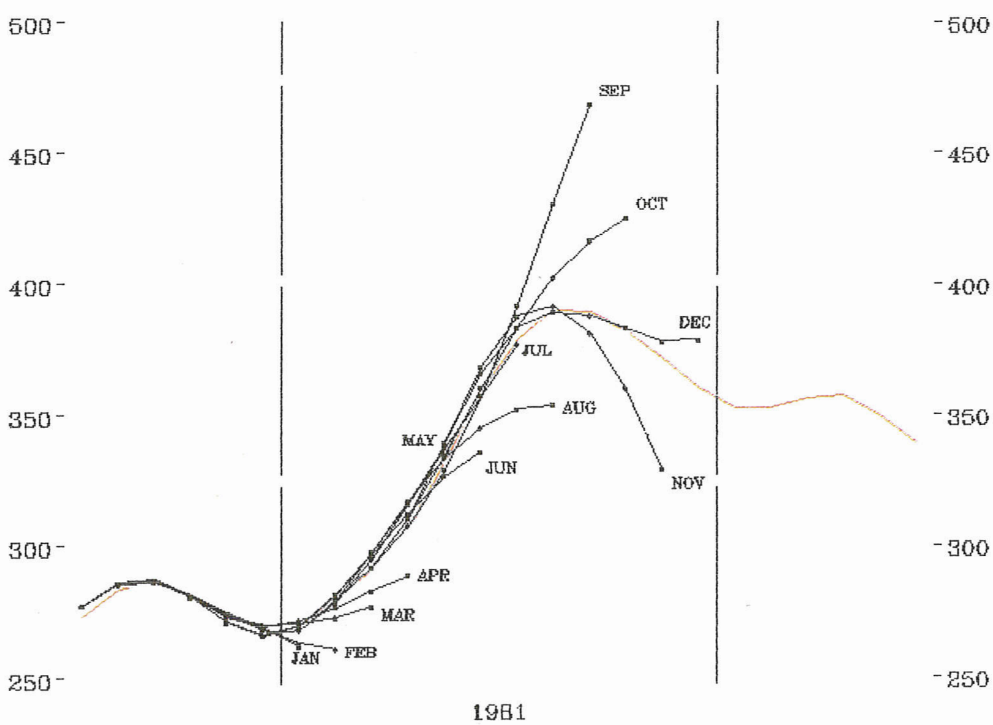
TOTAL UNEMPLOYED PERSONS
SENSITIVITY ANALYSIS AT MARCH 1986



GRAPH .23.

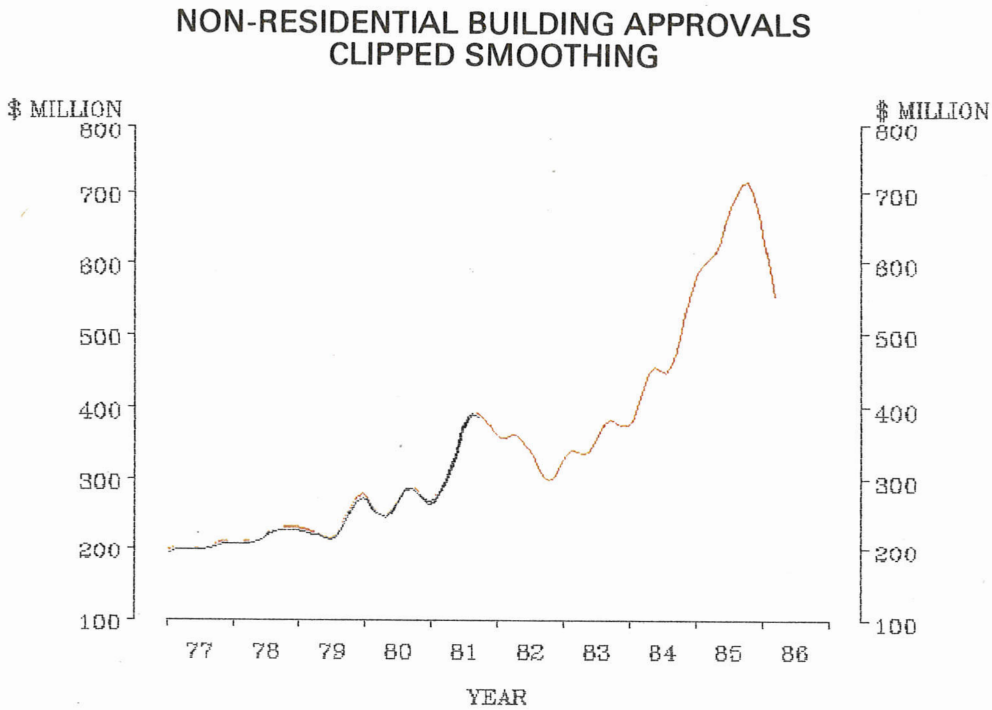
NON-RESIDENTIAL BUILDING APPROVALS
SMOOTHING SIMULATION

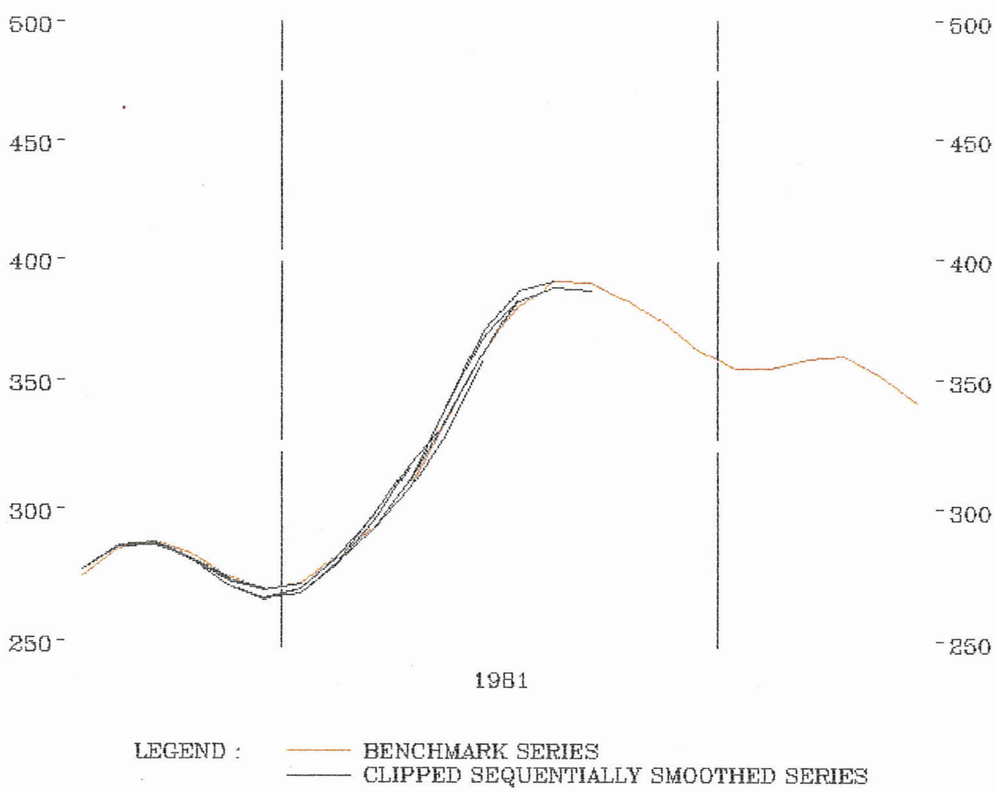




LEGEND : BENCHMARK SERIES
SEQUENTIALLY SMOOTHED SERIES

GRAPH .24.


NON-RESIDENTIAL BUILDING APPROVALS
CLIPPED SMOOTHING
$ MILLION
800
700
600
500
400
300
200
100
$ MILLION
800
700
600
500
400
300
200
100
77
78
79
80
81
82
83
84
85
86
YEAR


500
450
400
350
300
250
500
450
400
350
300
250
1981
LEGEND :
BENCHMARK SERIES
CLIPPED SEQUENTIALLY SMOOTHED SERIES

Growth decomposition

52. Given publication of smoothed seasonally adjusted series with seasonally adjusted and original series, analysts may decompose the monthly growth movements of the original series into the "seasonal's", trend's and residual's/irregular's contributions. How this decomposition is performed is illustrated in Table .6. below. Column 1 of the table gives the percentage monthly movements of the original Unemployed Australians series. These movements are accounted for by the percentage movements appearing in Columns 3 to 5, which represent the percentage movements respectively of the seasonal influences, trend and residual/irregular influences. Column 3 is obtained by dividing the original by the seasonally adjusted series so as to obtain a measure of the multiplicative seasonal factors; in more complex cases this measure would represent the net effect of evolving seasonality, trading-day and movable holiday influences. The monthly percentage movements in this "seasonality" measure appear in Column 3. The residual/irregular influences are obtained by dividing the seasonally adjusted series by the trend estimates. The monthly percentage movements in this measure appear in Column 5. Columns 4 and 6 are the monthly percentage movements of the smoothed and seasonally adjusted series respectively. Column 2 of the table is the summation of Columns 3 to 5. In relation to Column 1 it provides a clear indication of the approximate nature of the "accounting" for growth. For instance, consider the original series growth of 5.74% from December 1985 to January 1986. The table shows that 4.55 percentage points of this growth were attributed to seasonal influences, 0.58 to trend changes, and 0.56 to irregular influences, all working in the same direction. The seasonally adjusted movement was 1.14%. Column 2 shows that the approximation is a good one; 5.69 compared to 5.74. On the other hand the June/July 1986 growth of the original series is similar at 5.75%, but Column 2 shows that the approximation is not so accurate; 6.01 compared to 5.75. However, the decomposition is still useful as an indicative rather than precise one. In this instance the trend is estimated to have contributed 1.14 percentage points to this growth, and the irregular influences the large amount of 8.58. Seasonal influences have this time acted to moderate these increases, by contributing -3.70 percentage points. The seasonally adjusted movement is now 9.81% compared to the 1.14% December/January 1986 growth. In this example it is evident that neither the movements in the original nor seasonally adjusted series provide good indications of the trend's growth.

TABLE .6.

Growth decomposition
Unemployed Australians

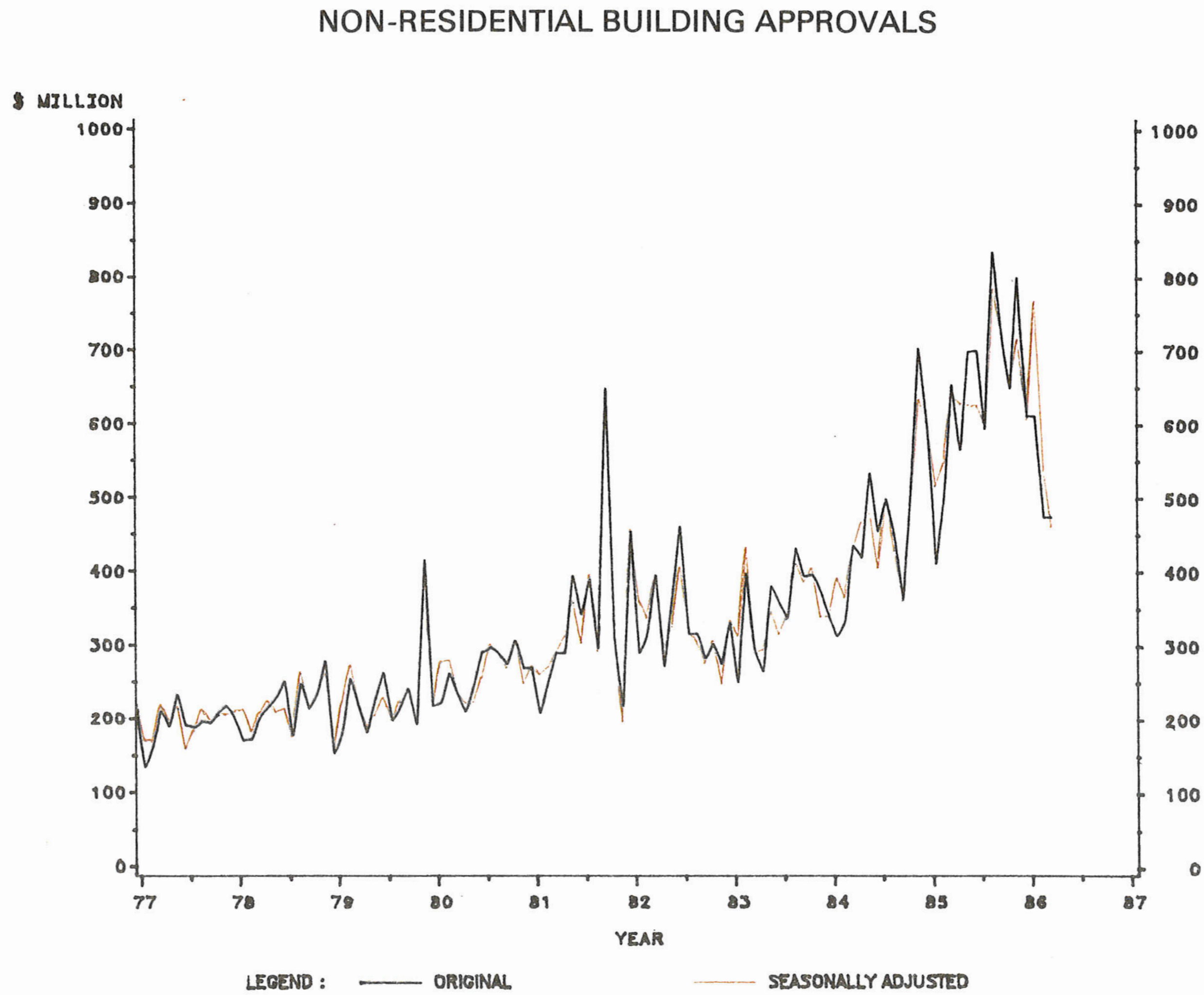
	Percentage monthly movement of:					
	Column 1	*Column 2*	*Column 3*	*Column 4*	*Column 5*	*Column 6*
Period	*Original series* O	*Sum* S+T+R	*Seasonal influences* S	*Trend (smoothed seasonally adjusted)* T	*Residual/ irregular influences* R	*Seasonally adjusted series* A÷T+R
1986—						
JAN	5.74	5.69	4.55	0.58	0.56	1.14
FEB	6.42	6.30	2.78	0.59	2.93	3.54
MAR	-3.45	-3.46	-2.50	0.64	-1.60	-0.97
APR	-5.23	-5.11	-6.89	0.69	1.09	1.78
MAY	-2.42	-2.41	-0.54	0.84	-2.71	-1.89
JUN	-5.13	-5.16	-2.90	1.02	-3.28	-2.29
JUL	5.75	6.01	-3.70	1.14	8.58	9.81
AUG	0.25	0.28	1.13	1.04	-1.88	-0.87

Practical considerations

Removing extremes before smoothing

53. With reference to Graph .25. below it can be seen just how irregular the month to month movements of the original and seasonally adjusted series of nonresidential building approvals are. It is not surprising that in the presence of such large irregularity the provisional estimates of trend are revised so extensively. One might ask whether pre-modifying some of the large irregulars would help improve the reliability of the smoothed estimates. The answer is that in principle such a procedure should help, provided the modification was reliable and not conjectural. Earlier, in paragraph 8, it was mentioned that the Australian Bureau of Statistics has generally found it difficult to quantify what amount of a particular observation may or may not be a genuine large irregular, particularly at the end of the series where invariably only hindsight enables perception of what is trend or irregular behaviour. Essentially trend and irregular behaviour cannot be inferred confidently without taking into account the local history *about* the point of interest; such history only partly exists at the end of the series.

GRAPH .25.



Pre-smoothing policy

54. For a number of pragmatic considerations the Australian Bureau of Statistics has not smoothed seasonally adjusted data that have been directly modified for extreme irregulars. The reasons for this policy are listed below, and are not ranked in any order.

(1) Statistical procedures for modifying "outliers" or "extremes" are generally inferior at the current end of the series.

(2) Timely subject matter information for quantifying the "extremes" is generally lacking.

(3) The practice of modifying the seasonally adjusted series before smoothing could lead to serious and controversial charges concerning the Bureau's objectivity.

(4) The applied smoothing procedure is impartial and neutral in that any user could replicate the published results.

(5) The smoothing process can be "additive" in its application, and thereby should provide consistency between sums of smoothed components and totals.

This policy has the disadvantage that in some instances the smoothed series might respond unnecessarily to the presence of a very large irregular. However, this potential problem is somewhat moderated by the fact that the smoothed series are generally presented with the seasonally adjusted series, the latter never being modified for extreme irregulars, so the user can subjectively judge whether the smoothed series have responded in an unwarranted manner. More generally, Table .7. below shows what proportion of a specific and singular disturbance or perturbation would pass into the estimates of trend at various points in time. Usually, however, the residual/irregularity in the series chops and changes direction and magnitude from month to month, and in the averaging process tends to be dampened out to a much greater extent than might be implied by the table below.

TABLE .7.

PROPORTION OF SPECIFIC PERTURBATION IN MONTH M PASSING TO TREND ESTIMATES

As at:	*Month of interest:*												
	M-6	*M-5*	*M-4*	*M-3*	*M-2*	*M-1*	*M*	*M + 1*	*M + 2*	*M + 3*	*M + 4*	*M + 5*	*M + 6*
M	-0.019	-0.034	-0.018	0.046	0.148	0.279	0.421	0	0	0	0	0	0
M + 1	,,	-0.028	-0.006	0.050	0.131	0.216	0.292	0.353	0	0	0	0	0
M + 2	,,	,,	0	0.061	0.136	0.201	0.241	0.254	0.244	0	0	0	0
M + 3	,,	,,	,,	0.066	0.144	0.205	0.230	0.216	0.174	0.120	0	0	0
M + 4	,,	,,	,,	,,	0.147	0.212	0.235	0.208	0.149	0.080	0.012	0	0
M + 5	,,	,,	,,	,,	,,	0.214	0.238	0.210	0.145	0.068	0.002	-0.058	0
M + 6	,,	,,	,,	,,	,,	,,	0.240	0.213	0.145	0.066	0.003	-0.038	-0.092
M + 7	,,	,,	,,	,,	,,	,,	,,	0.214	0.147	0.067	0.004	-0.025	-0.043
M + 8	,,	,,	,,	,,	,,	,,	,,	,,	0.147	0.066	0.003	-0.022	-0.016
M + 9	,,	,,	,,	,,	,,	,,	,,	,,	,,	0.066	0.001	-0.022	-0.009
M + 10	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	0	-0.025	-0.011
M + 11	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	-0.028	-0.017
M + 12, etc	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	-0.019

Additivity

55. The issue of "additivity" was mentioned above with regard to smoothed series. "Additivity" means that two or more smoothed component series can be added or subtracted to produce the same result as smoothing the sum or difference, directly in its own right. For example, summing unemployed and employed to produce labour force, summing males and females to produce persons, or differencing exports and imports to produce balance of trade. For consistent results to prevail in these circumstances, that is, for the smoothing process to be additive, three conditions must be satisfied:

(1) the addition (subtraction) of the seasonally adjusted components must equal the seasonally adjusted sum (difference), that is, the seasonally adjusted series must be consistent

(2) none of the seasonally adjusted series are modified for extreme irregulars prior to smoothing

(3) all of the seasonally adjusted series are smoothed with the same type of moving average.

Multiplicativity

56. Similar to the "additivity" question is the issue of whether the multiplication or division of smoothed components would produce the same result as smoothing directly the products or ratios. For instance, would dividing smoothed unemployment by smoothed labour force produce the same result as smoothing the unemployment rate itself? Generally one procedure approximates the other very well. Differences tend to be greatest, however, when:

- the component series are highly irregular and the resultant series is much less irregular due to cancelling effects between observations;
- a component series contains sharp turning-points or steep regions of inflexion which affect its smoothing, but these become reduced or enlarged during the production of the resultant series;
- the component series oscillate rapidly from positive to negative values, producing smoothed values close to zero and consequently induce problems of numerical accuracy.

As a general rule, where smoothed components exist it is better to manipulate them arithmetically to obtain sums, differences, products or ratios, thereby avoiding two explicit measures of the same thing.

Filter length

57. It was mentioned above in paragraph 55 that one condition for "additivity" was that each series be smoothed with the same moving average. Presently the Australian Bureau of Statistics directly smooths seasonally adjusted series with only Henderson moving averages, so there is no conflict involving the use of different classes of moving averages. However, there are different length symmetric Henderson moving averages available for selection. Until recently there were available for smoothing monthly data 9, 13 and 23 term Henderson averages, and a 5 term for quarterly series. The Bureau has now added to this set the 7, 15 and 17 term Henderson averages.

58. Selection of any one particular length Henderson moving average should in principle be determined by a specific set of user determined objectives regarding damping of specified unwanted cycles, phase shift, revision and timeliness. Filter selection is also related to what cycles are present to varying degrees in the data to be smoothed. For instance a user may wish to have dampened all cycles whose length are shorter than one year, however, if the data contains only short-term cyclical variations in the range of four months or less the use of a 9 term Henderson would be satisfactory and a 13 term Henderson would be unnecessary (refer to *Graph* .13.). In other instances the data may be so volatile that a 23 term Henderson is indicated as desirable to achieve the damping objective. However, the issue of many revisions, timeliness and phase shift associated with a 23 term Henderson's eleven surrogate moving averages is such that it may not be considered practicable, and consequently a shorter Henderson moving average may be selected as a compromise.

59. For general application to quite erratic monthly series the Australian Bureau of Statistics has found that the 13 term Henderson moving average has been a suitable filter for satisfying general user needs. As user requirements become specialised the use of this particular filter will require further review.

Other considerations

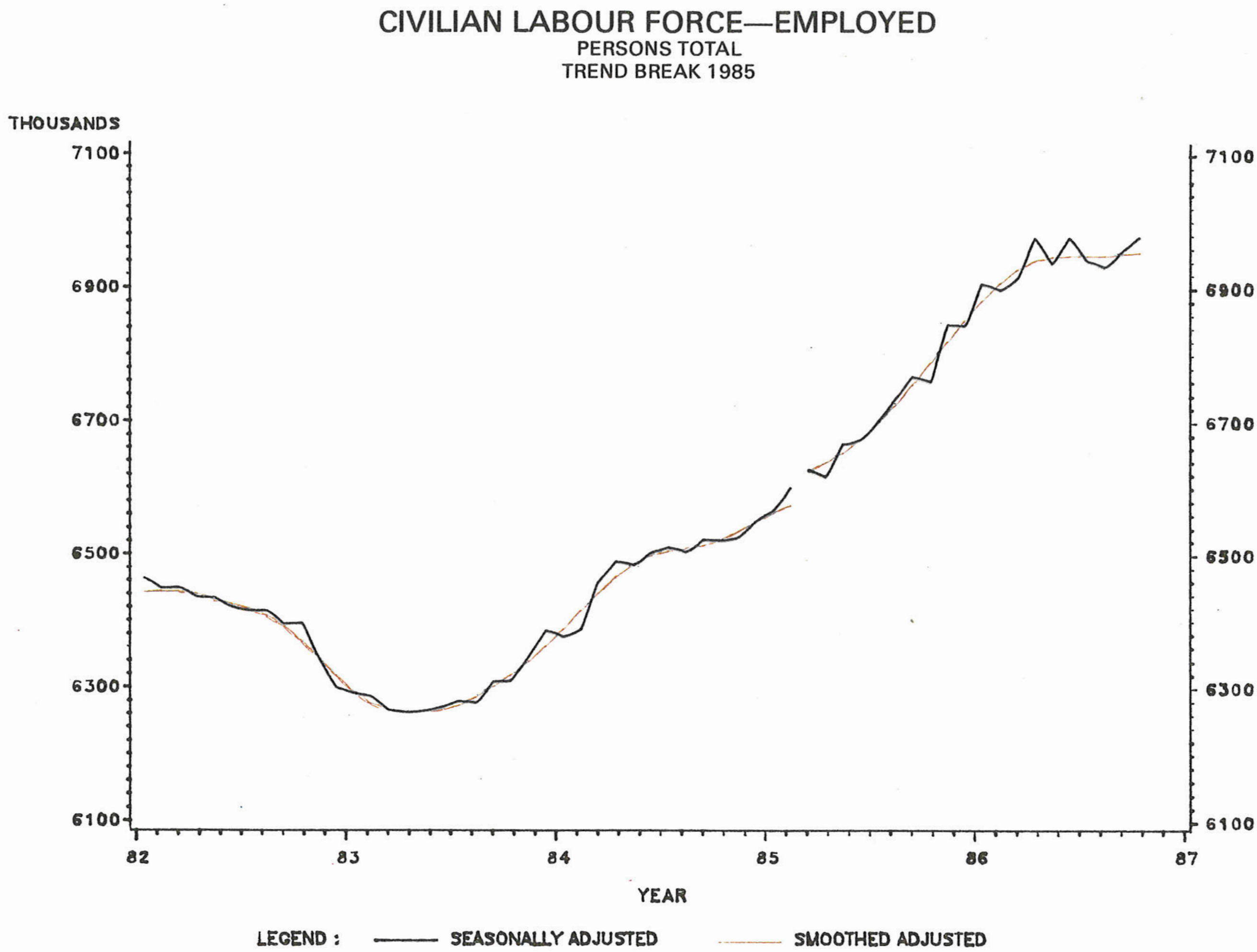
60. There are a number of practical considerations to note when smoothing series. Firstly, the Henderson moving averages should not be applied to time series that contain annual seasonal patterns, because such patterns would remain in the smoothed series. Consequently, only data that is seasonally adjusted or non-seasonal to start with should be smoothed. For reliable seasonal adjustment, generally more than five years of data is required. If a time series is non-seasonal the shortest period of data that could be smoothed by a symmetric 13 term Henderson moving average is 13 months — the first and last six smoothed values being obtained by using the Henderson's surrogate moving averages.

61. In addition to the above consideration of data length there is the issue of trend-breaks, that is the occurrence of a sharp and abrupt dislocation of the trend path between two months. Trend breaks may arise because of data re-classification or new/different data collection/compilation procedures. Graph .26. below illustrates a trend break in Total Employed Persons, as a result of reclassifying Unpaid Family Helpers, between February and March 1985. If the presence of trend breaks are ignored and smoothed over, up to twelve estimates of the estimated trend will be in error; six estimates either side of the break will be over or underestimated or vice versa as illustrated below in Graph .27.

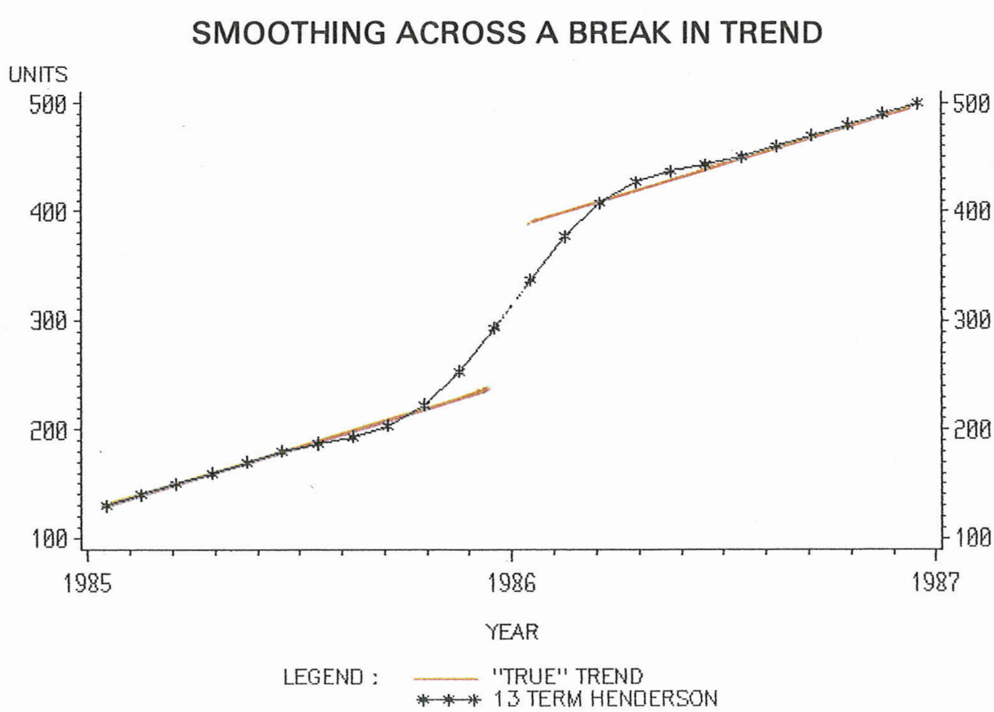
62. When a trend break is known to have occurred in the data the series should be treated as effectively two series — one ending at the break and the other commencing from the break. Consequently, trend breaks at the current end of the series pose problems for producing timely and reliable trend indicators until sufficient data concerning the new trend path have become available.

63. Another practical consideration is that such estimates of trend, as described in this paper, are not estimates of a single, absolute and unequivocally defined TREND of some real world activity. Such an observable TREND does not exist. The statistical measures of trend are estimates conditioned by the nature of the time series from which they are wrought. For instance, if unemployment data were collected every third month, say, February, May, August and November, the trend estimate from this quarterly time series could be at a different level to that obtained from a monthly unemployment series incorporating the four above monthly estimates. How this may happen is illustrated below by an extreme example. Suppose all February, May, August and November unemployment numbers are essentially equal to each other year after year. The perceived trend would be a straight line passing through all these months. If, however, the monthly data disclosed that the two intervening months were seasonally lower than February, May, August and November, then obviously the trend in the monthly series is lower than that in the quarterly series which shares four of the twelve months. Neither estimate of trend level is wrong, it is just specific to a certain time series. The important question that needs to be asked here is: "Just how close does the original data reflect the behaviour of the real world?". One consolation, even in this paradoxical example, is that movements in either trend estimates are likely to be similar, even though the levels may differ.

GRAPH .26.



GRAPH .27.



Conclusion

64. At any point of time an original observation in a time series is determined simultaneously by the interaction of the behaviour of its changing seasonal pattern, evolving trading-day and movable holiday influences, varying trend path and erratic residual short-term effects. Consequently, movements in the original data are not good proxies of trend behaviour, be they movements over a span of one year, three months, or the latest month.

65. Movements in seasonally adjusted time series are a function only of the varying trend path and the erratic residuals. Consequently, if a series is highly volatile the seasonally adjusted series will not be a good proxy of the trend behaviour either. Only when the influence of the erratic residual is dampened appreciably will the smoothed seasonally adjusted series act as an indicator of trend behaviour, albeit a nebulous and non-absolute measure.

66. To smooth monthly seasonally adjusted series the Australian Bureau of Statistics uses a cost effective procedure that is an integral and major part of its seasonal analysis process. The filter used is generally the 13 term Henderson moving average, which is known to have certain desirable time series characteristics as discussed above.

67. Generally these indicators of trend behaviour are, with the exception of the last two or three current estimates, subject to relatively little revision. As a general rule, reliable conclusions about trend behaviour may be made from the smoothed seasonally adjusted series excluding the last three estimates. The last three estimates are always provisional and subject to the largest relative revision. These estimates, therefore, should only be used very cautiously, and in conjunction with anecdotal or other information if more timely indicators of trend behaviour are required. They should not be used alone to conclude that a turning point or point of inflexion has just occurred in the series.

68. It is an inexorable fact of life that it is not possible to reliably ascertain what the current trend is from the most recent monthly movement alone. Those that say they can should recognise that they are claiming to be able to accurately decompose the current original movement into a changing trend path, varying seasonal pattern, evolving trading-day and movable holiday influence, as well as temporary irregular effects. To repeat accurately such a task every month is known by experienced statisticians to be impossible.

APPENDIX A

Henderson moving average weights

5-Term Henderson

Trend-cycle value for period	*Weight given to seasonally adjusted values in period*				
	N-4	*N-3*	*N-2*	*N-1*	*N*
N	0	0	-.073	.403	.670
N-1	0	-.073	.294	.522	.257
N-2	-.073	.294	.558	.294	-.073

7-Term Henderson

Trend-cycle value for period	*Weight given to seasonally adjusted values in period*						
	N-6	*N-5*	*N-4*	*N-3*	*N-2*	*N-1*	*N*
N	0	0	0	-0.034	0.116	0.383	0.535
N-1	0	0	-0.054	0.061	0.294	0.410	0.289
N-2	0	-0.053	0.058	0.287	0.399	0.275	0.034
N-3	-0.059	0.059	0.294	0.412	0.294	0.059	-0.059

9-Term Henderson

Trend-cycle value for period	*Weight given to seasonally adjusted values in period*								
	N-8	*N-7*	*N-6*	*N-5*	*N-4*	*N-3*	*N-2*	*N-1*	*N*
N	0	0	0	0	-.156	-.034	.185	.424	.581
N-1	0	0	0	-.049	-.011	.126	.282	.354	.298
N-2	0	0	-.022	0	.120	.259	.315	.242	.086
N-3	0	-.031	-.004	.120	.263	.324	.255	.102	-.029
N-4	-.041	-.010	.119	.267	.330	.267	.119	-.010	-.041

13-Term Henderson

Trend-cycle value for period	*Weight given to seasonally adjusted values in period*												
	N-12	*N-11*	*N-10*	*N-9*	*N-8*	*N-7*	*N-6*	*N-5*	*N-4*	*N-3*	*N-2*	*N-1*	*N*
N	0	0	0	0	0	0	-.092	-.058	.012	.120	.244	.353	.421
N-1	0	0	0	0	0	-.043	-.038	.002	.080	.174	.254	.292	.279
N-2	0	0	0	0	-.016	-.025	.003	.068	.149	.216	.241	.216	.148
N-3	0	0	0	-.009	-.022	.004	.066	.145	.208	.230	.201	.131	.046
N-4	0	0	-.011	-.022	.003	.067	.145	.210	.235	.205	.136	.050	-.018
N-5	0	-.017	-.025	.001	.066	.147	.213	.238	.212	.144	.061	-.006	-.034
N-6	-.019	-.028	0	.066	.147	.214	.240	.214	.147	.066	0	-.028	-.019

15-Term Henderson

Trend-cycle value for period	*Weight given to seasonally adjusted values in period*														
	N-14	*N-13*	*N-12*	*N-11*	*N-10*	*N-9*	*N-8*	*N-7*	*N-6*	*N-5*	*N-4*	*N-3*	*N-2*	*N-1*	*N*
N	0	0	0	0	0	0	0	-0.079	-0.057	-0.014	0.057	0.149	0.244	0.325	0.375
N-1	0	0	0	0	0	0	-0.040	-0.039	-0.016	0.034	0.105	0.180	0.240	0.270	0.265
N-2	0	0	0	0	0	-0.016	-0.025	-0.013	0.027	0.088	0.152	0.202	0.221	0.205	0.159
N-3	0	0	0	0	-0.005	-0.018	-0.010	0.026	0.083	0.143	0.189	0.205	0.185	0.135	0.069
N-4	0	0	0	-0.005	-0.018	-0.010	0.026	0.082	0.143	0.188	0.203	0.183	0.133	0.067	0.006
N-5	0	0	-0.008	-0.020	-0.011	0.025	0.083	0.144	0.191	0.207	0.188	0.139	0.074	0.014	-0.026
N-6	0	-0.012	-0.023	-0.013	0.025	0.083	0.146	0.193	0.210	0.192	0.144	0.080	0.021	-0.017	-0.028
N-7	-0.014	-0.024	-0.014	0.024	0.083	0.146	0.194	0.212	0.194	0.146	0.083	0.024	-0.014	-0.024	-0.014

APPENDIX A—*continued*

17-Term Henderson

Trend-cycle value for period	Weight given to seasonally adjusted values in period																
	N-16	*N-15*	*N-14*	*N-13*	*N-12*	*N-11*	*N-10*	*N-9*	*N-8*	*N-7*	*N-6*	*N-5*	*N-4*	*N-3*	*N-2*	*N-1*	*N*
N	0	0	0	0	0	0	0	0	-0.081	-0.062	-0.032	0.018	0.087	0.166	0.244	0.309	0.350
N-1	0	0	0	0	0	0	0	-0.042	-0.040	-0.026	0.007	0.059	0.121	0.182	0.230	0.255	0.254
N-2	0	0	0	0	0	0	-0.017	-0.025	-0.020	0.004	0.047	0.100	0.152	0.191	0.206	0.197	0.164
N-3	0	0	0	0	0	-0.005	-0.016	-0.015	0.005	0.043	0.092	0.140	0.174	0.186	0.172	0.136	0.086
N-4	0	0	0	0	-0.001	-0.013	-0.014	0.005	0.043	0.091	0.138	0.171	0.181	0.167	0.129	0.078	0.026
N-5	0	0	0	-0.003	-0.015	-0.015	0.005	0.043	0.091	0.138	0.172	0.183	0.169	0.132	0.081	0.029	-0.012
N-6	0	0	-0.006	-0.017	-0.016	0.004	0.043	0.092	0.140	0.174	0.186	0.173	0.137	0.087	0.036	-0.005	-0.027
N-7	0	-0.009	-0.019	-0.018	0.003	0.042	0.092	0.141	0.176	0.188	0.175	0.140	0.091	0.040	0.001	0.021	0.023
N-8	-0.010	-0.020	-0.019	0.002	0.042	0.092	0.141	0.176	0.189	0.176	0.141	0.092	0.042	0.002	-0.109	-0.020	-0.010

23-Term Henderson—*continued below*

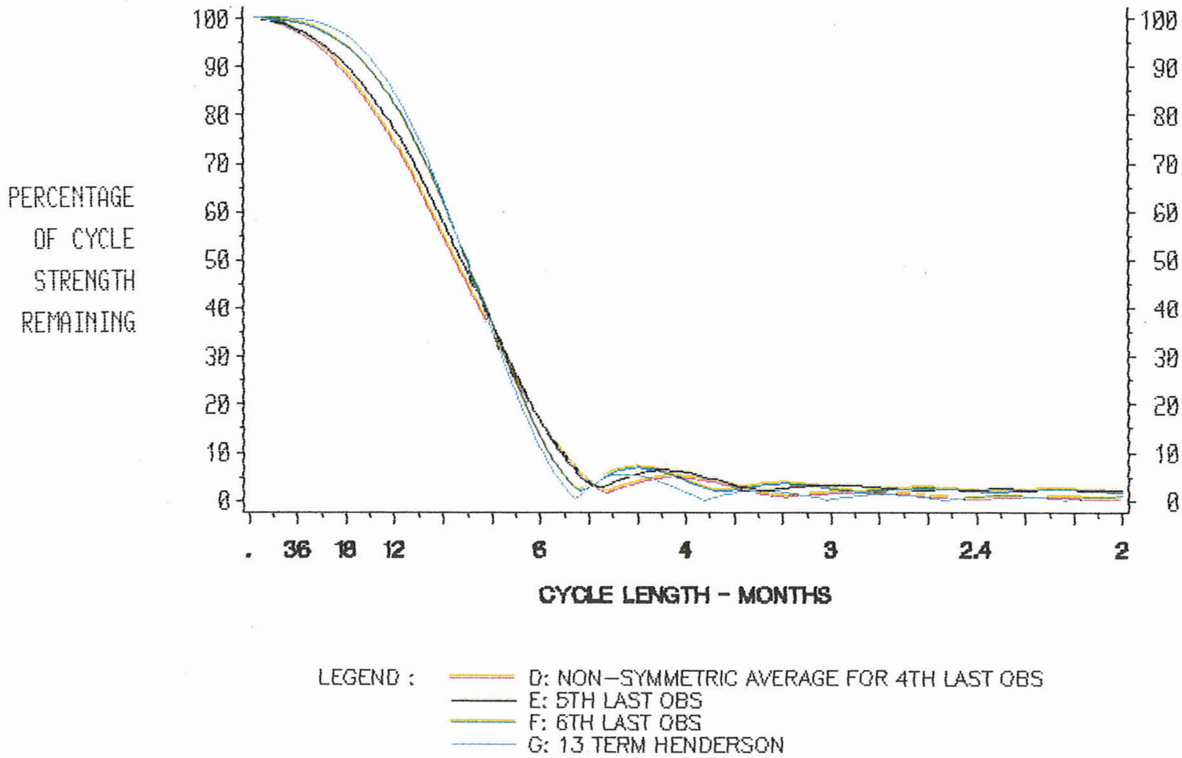
Trend-cycle value for period	Weight given to seasonally adjusted values in period											
	N-22	*N-21*	*N-20*	*N-19*	*N-18*	*N-17*	*N-16*	*N-15*	*N-14*	*N-13*	*N-12*	*N-11*
N	0	0	0	0	0	0	0	0	0	0	0	-.077
N-1	0	0	0	0	0	0	0	0	0	0	-.046	-.041
N-2	0	0	0	0	0	0	0	0	0	-.022	-.025	-.025
N-3	0	0	0	0	0	0	0	0	-.008	-.014	-.018	-.015
N-4	0	0	0	0	0	0	0	-.001	-.008	-.013	-.012	-.003
N-5	0	0	0	0	0	0	.003	-.006	-.011	-.011	-.002	.015
N-6	0	0	0	0	0	.002	-.006	-.012	-.011	-.003	.015	.039
N-7	0	0	0	0	.001	-.007	-.013	-.011	-.003	.015	.039	.068
N-8	0	0	0	-.002	-.007	-.013	-.013	-.003	.014	.039	.068	.097
N-9	0	0	-.003	-.010	-.015	-.014	-.005	.014	.040	.069	.097	.122
N-10	0	-.004	-.011	-.016	-.015	-.005	.013	.039	.068	.097	.122	.138
N-11	-.004	-.011	-.016	-.015	-.005	.013	.039	.068	.097	.122	.138	.148

23-Term Henderson—*continued*

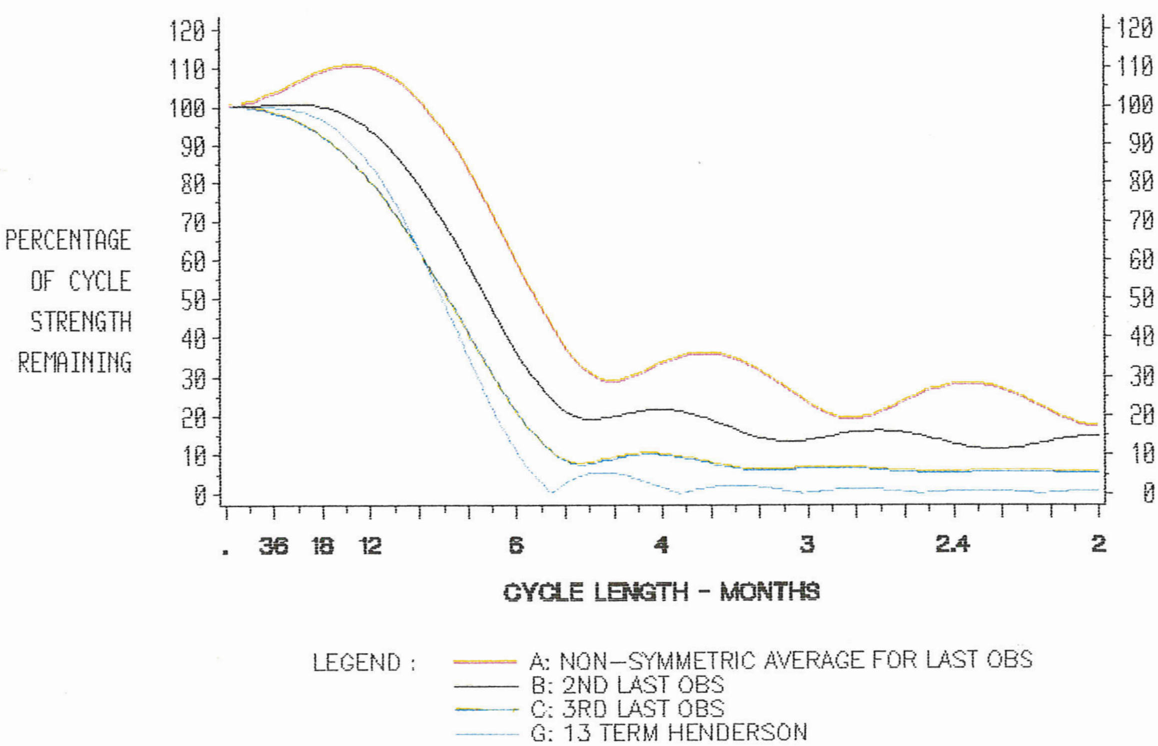
Trend-cycle value for period	Weight given to seasonally adjusted values in period										
	N-10	*N-9*	*N-8*	*N-7*	*N-6*	*N-5*	*N-4*	*N-3*	*N-2*	*N-1*	*N*
N	-.064	-.049	-.028	.002	.039	.084	.133	.182	.227	.263	.288
N-1	-.035	-.024	-.004	.025	.061	.101	.141	.176	.203	.219	.224
N-2	-.019	-.005	.018	.049	.082	.116	.146	.166	.177	.176	.166
N-3	-.004	.015	.042	.073	.103	.129	.147	.154	.150	.134	.112
N-4	.015	.040	.068	.098	.121	.137	.142	.135	.119	.095	.066
N-5	.039	.067	.095	.119	.134	.139	.131	.114	.088	.059	.027
N-6	.068	.096	.118	.134	.138	.132	.114	.089	.059	.027	.001
N-7	.096	.120	.135	.140	.133	.116	.090	.060	.031	.005	-.015
N-8	.120	.137	.140	.136	.118	.094	.064	.034	.008	-.010	-.021
N-9	.138	.143	.137	.120	.095	.067	.037	.011	-.007	-.017	-.019
N-10	.144	.138	.122	.097	.068	.039	.013	-.005	-.015	-.016	-.011
N-11	.138	.122	.097	.068	.039	.013	-.005	-.015	-.016	-.011	-.004

APPENDIX B

EFFECT OF 13 TERM HENDERSON AND ITS FIRST THREE SURROGATES ON CYCLES



EFFECT OF 13 TERM HENDERSON AND ITS LAST THREE SURROGATES ON CYCLES



APPENDIX C

Simple sensitivity analysis

Consider seasonally adjusted data being available up to the last month, M. The last but one month is M-1, the last but sixth month is M-6, and the next month is M+1. Column 1 in the table below shows what proportion of the seasonally adjusted data up to month M determines the first estimate of the smoothed seasonally adjusted data for month M (refer to Table .3. and paragraph 36). Column 2 of the table shows what proportion of the seasonally adjusted data up to next month M+1 determines the second estimate of the smoothed seasonally adjusted series for month M. The first revision to the current estimate of trend in month M is therefore the difference between the estimates derived from columns 2 and 1. Column 3 of the table shows what proportions of the seasonally adjusted data up to next month M+1 determines the first revision to the trend estimate for month M.

	Column 1	*Column 2*	*Column 3*
M+1	—	0.279	0.279
M	0.421	0.292	-0.129
M-1	0.353	0.254	-0.099
M-2	0.244	0.174	-0.070
M-3	0.120	0.080	-0.040
M-4	0.012	0.002	-0.010
M-5	-0.058	-0.038	+0.020
M-6	-0.092	-0.043	+0.049

From column 3 the sensitivity formula below is derived:

M+1 = [Revision + 0.129**M** + 0.099 **M-1** + 0.07 **M-2** + 0.04 **M-3** + 0.01 **M-4** - 0.02 **M-5** -0.049 **M-6]** ÷ 0.279

The various **Ms** represent the seasonally adjusted data for the respective months, and "Revision" is the user specified amount of revision in which there is interest. For example, if the revision discussed in paragraph 48 is to be in Case 1, -10.7 = 582.4-593.1, then given the seasonally adjusted data to month M we have from above—

M+1 = [-10.7 + 0.129 (595.6) + 0.099 (600.0) + 0.07 (583.3) + 0.04 (574.2) + 0.01 (587.4) -0.02 (575.0) -0.049 (590.9)] ÷ 0.279

= 554.7

In case 2 we have:

M+1 = [(612.4-593.1) + 0.129 (595.6) + 0.099 (600.0) + 0.07 (583.3) + 0.04 (574.2) + 0.01 (587.4) -0.02 (575.0) -0.049 (590.9)] ÷ 0.279

= 662.2

In Case 3 we have:

M+1 = [0.0 + 0.129 (595.6) + 0.099 (600.0) + 0.07 (583.3) + 0.04 (574.2) + 0.01 (587.4) -0.02 (575.0) -0.049 (590.9)] ÷ 0.279

= 593.0

In some circumstances users may be interested in knowing what the next month's seasonally adjusted figure would need to be for a certain percentage movement to occur between the latest two trend estimates. Below, the required formula to ascertain this is given:

M+1 = [Percent change x (0.292 **M** + 0.254 **M-1** + 0.174 **M-2** + 0.08 **M-3** + 0.002 **M-4** -0.038 **M-5** -0.043 **M-6**) -100 (0.061 **M**-0.01 **M-1** -0.054 **M-2** -0.068 **M-3** -0.06 **M-4** -0.054 **M-5** +0.043 **M-6**)] ÷ (14.2 - Percent change x 0.279)